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ORIGINAL ARTICLE

Contagious Bovine Pleuropneumonia Vaccine Delivery and Adoption by Women and Men in North-Eastern Kenya

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Abstract Contagious bovine pleuropneumonia (CBPP) is an endemic transboundary disease of cattle controlled by vaccination, with a vaccine characterized by low efficacy and safety. To contribute towards its eradication, social scientists have sought ways of improving the delivery and adoption of the vaccine, whereas vaccine scientists have attempted to develop safer and more efficacious vaccines. To understand the status of CBPP vaccine delivery and the effect of gender on vaccine adoption, qualitative and quantitative data were collected from vaccine delivery stakeholders, including men and women cattle owners from north-eastern Kenya. The results indicate that the main constraints to vaccine delivery include restricted distribution due to stringent government regulation and the need for a cold supply chain, which is exacerbated by poor transport infrastructure. On vaccine adoption, men and women accepted the vaccine, but men were willing to pay significantly higher prices than women because they were significantly wealthier.

Résumé La péripneumonie contagieuse bovine (PCB) est une maladie transfrontalière endémique des bovins contrôlés par la vaccination, avec un vaccin caractérisé par une faible efficacité et une faible sécurité. Pour contribuer à son éradication, les chercheurs en sciences sociales ont cherché des moyens d'améliorer l'administration et l'adoption du vaccin, tandis que les scientifiques du vaccin ont tenté de développer des vaccins plus sûrs et plus efficaces. Pour comprendre le statut de l'administration

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du vaccin PCB et l'effet du genre sur l'adoption des vaccins, des données qualitatives et quantitatives ont été recueillies auprès des acteurs de la vaccination, notamment des hommes et des femmes propriétaires de bétail au nord-est du Kenya. Les résultats indiquent que les principales contraintes à l'administration des vaccins comprennent une distribution restreinte en raison de la réglementation gouvernementale rigoureuse et de la nécessité de la chaîne du froid, qui est exacerbée par une infrastructure de transport médiocre. En ce qui concerne l'adoption des vaccins, les hommes et les femmes ont accepté le vaccin, mais les hommes étaient disposés à payer des prix sensiblement plus élevés que les femmes parce qu'ils étaient sensiblement plus riches.

Keywords Cattle · Vaccine · Delivery · Adoption · Gender · Kenya · Gender Studies · Economics

Introduction

Vaccination services for humans and livestock often fail to achieve sufficient coverage in Africa's remote rural settings because of financial, logistical, and service delivery challenges (Schelling et al. 2005, 2007). While the term delivery in vaccine language mainly means the (safest) form and route that a vaccine is administered (Khan 2011), in this study, the term vaccine delivery represents the multiple processes that take place between the release of the vaccine by the manufacturer to when it reaches the end user. Once a vaccine becomes accessible to the end user, it can be adopted. In this study, we have developed an operational definition of adoption to be the taking-up of a product (vaccine) recommended for use. Adoption could be a one-off use for a one-off use vaccines, or repeated use for repeated use vaccines. Vaccine adoption by a client, like the adoption of other technologies, is determined by its accessibility, affordability and acceptability (Waithanji et al. 2015). Past studies on vaccine delivery have focused on the adoption of the vaccine by the client (Heffernan and Misturelli 2000; Kairu-Wanyoike et al. 2014) without considering the distribution process and gender differences in adoption.

Technology adoption is gendered. Women access and adopt fewer technologies and at a lower rate than men, for almost all agricultural (Doss 2001; Behera and Behera 2013; Meinzen-Dick et al. 2011) and livestock (Johnson et al. 2013; Mburu et al. 2013; Quisumbing et al. 2013; Waithanji et al. 2015) technologies. This difference in adoption between men and women is associated with gender-based norms that are unfavorable for women, situating them in disadvantageous positions to access technologies in relation to men. The study reported in this paper seeks to answer two main questions: what is the status of CBPP delivery and how does gender affect the adoption of contagious bovine pleuropneumonia (CBPP) vaccine in Ijara subcounty, Garissa County, north-eastern Kenya?

The findings from this study are intended to inform stakeholders of the CBPP vaccine about the status of delivery of the vaccine currently in use, and the potential of adoption, by end users, of improved versions of the vaccine currently under development in Kenya (hitherto described as the hypothetical vaccine). Findings from this

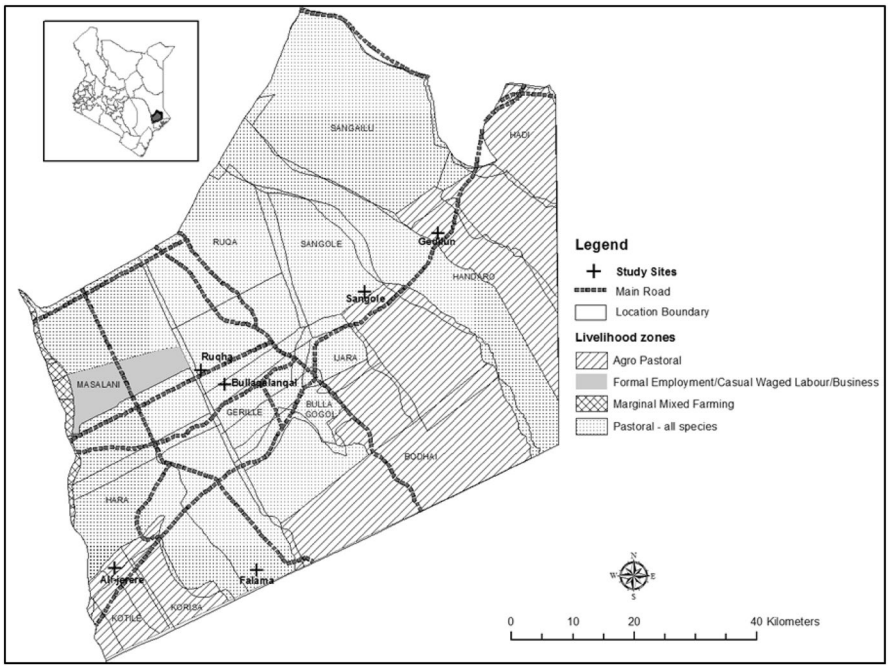


Fig. 1 The study area, showing the study sites. *Source* Authors

study will, therefore, enable these stakeholders to plan and implement the following. First, with the knowledge of the status of vaccine delivery, policy makers can put in place more efficient and effective delivery mechanisms for the vaccines under development. Second, the vaccine developers can factor in many characteristics, while prioritizing the most desirable ones, specified by women and men as key attributes of the new vaccine. Third, using the findings on adoption from the willingness to pay study, the vaccine developers will strive to develop a product that will retail at a price not deviating too much from the price range stated by those willing to pay for it. The results from this study will also provide information and direction on the potential for commercialization of this vaccine for sustainable delivery and use.

Materials and Methods

Study Area

The study was conducted in Ijara subcounty, Garissa County, north-eastern Kenya (Fig. 1). Ijara is in the southern part of Garissa County and borders Lamu County to the south. The predominant ethnic community in Ijara is the Somali of the *Abdalla* clan followed by the *Rer Mohammed* clan. Islam is the predominant religion and their main livelihood source is cattle raised in a transhumant production system.

Sampling

Ijara is a subcounty of Garissa County. Specific information about the predominantly transhumant pastoral population of Ijara has always been lost in the aggregated Garissa district development plans (before 2013) and now the County Government integrated plan (2014). Ijara rose from being a division to a subcounty during the devolution process that was initiated in 2013 and was still in its early transition stages at the time of the study (2014). Additionally, during the time of the study, the security of Ijara was on high alert to the threat of the *Al-Shabaab* militia who inhabit the Boni forest that borders Ijara and Lamu. Inter- and intra-clan tensions and fighting were reported during fieldwork. At the time of the study, government offices were deserted, with most officials recently posted to Ijara not having reported and previous ones having left their duty stations for their new positions in other places. It was, therefore, not possible to access comprehensive lists of pastoralists in Ijara that could be used as a sampling frame.

Owing to the lack of a pre-existing sampling frame, to reduce sampling bias and minimise sampling error, the authors used a combination of sampling methods. The Ijara subcounty livelihood map was constructed by the authors (Fig. 1) in consultation with key informants, as no such map existed. The livelihood map revealed four livelihood zones, pastoralism, agro-pastoralism, mixed farming and formal employment in businesses and government and non-governmental organizations. The study area of interest was the pastoral area. A multi-stage sampling technique was then used. In the first stage, Masalani, the subcounty headquarters, was eliminated because it is urban and had few cattle. The remaining five locations in the subcounties Kotile, Hulugo, Sangailu, Sangole and Ruqha were pastoral and were used for the second stage of sampling.

A list of all sublocations in each location was made. The sublocations experiencing clan conflicts were identified and removed from the list, and then one sublocation was selected per location using a simple random sampling technique. For each location, the names of the sublocations were placed in a small box and mixed, and a colleague was asked to pick one paper from the box. The selected sublocation was then documented. At the sublocation, the chief and some elders representing different clans were asked to identify 12 men and 12 women from cattle-owning households proportionately representing different clans and subclans as well as male-headed households (MHH) and female-headed households (FHH) in each sublocation's population, because there was no pre-existing list of men and women by clan/subclan from cattle-owning households.

Table 1 indicates the locations and final sublocations in Ijara that were selected, with the corresponding number of households interviewed from each location

Data Collection and Analysis

Vaccine Delivery Study

Data on vaccine delivery were collected through key informant interviews with animal health professionals and paraprofessionals/community animal disease reporters

Table 1 Focus group discussion composition

Name of location	Name of sublocation	Number of women	Number of men
Sangailu	Gedilun	12	11
Sangole	Sangole	8	12
Kotile	Alijarere	9	12
Hulugo	Falama	12	8
Ruqha	Ruqha	10	11
Ruqha	Ruqha (Bullaqalanqala)	10	12
	Total	61	66

(CADRs) involved in the vaccine supply chain and sex-disaggregated focus group discussions (FGD) with men and women hailing from cattle-owning households. The data were analyzed inductively by identifying trends, categorizing them, and building statements of conclusions from these categories. In some cases, responses by focus group discussants were translated into words or statements representing their meanings. The words/statements were then filtered, counted, and presented in the form of word clouds using the NVivo 10® software.

One field veterinarian and seven CADRs were interviewed as key informants on vaccine delivery. Only one CADR was a woman. A manager from the Kenya Veterinary Vaccine Production Institute (KEVEVAPI) was also interviewed and two GALVmed employees interviewed to validate information on GALVmed obtained from the internet (GALVmed 2010).

In addition to the responses by veterinarians and CADRs, chiefs who were available were also interviewed to give information about their locations. Two chiefs from Kotile and Sangailu and one senior chief from Sangole were interviewed. The chiefs were all men. The chiefs gave an overview of their communities and helped identify the distinct characteristics of their locations.

Data for vaccine delivery were analyzed using descriptive statistics (maximum, minimum, means, standard deviation, frequencies, etc.). To assess proportions, we opted for the proportion piling method in which participants are given 100 seeds/pebbles and asked to assume the total pebbles to represent the total population being discussed (Mayoux and Chambers 2005). Participants are then asked what proportion of the community owns cattle, or what is the ratio of men and women in the community. The pile of pebbles representing a category are then counted to represent the percentage of the population represented in the category.

New Vaccine Adoption Study

When introducing a new market or nonmarket product, the use of stated preference data (based on respondents' declaration) is a common method to assess buyers' preferences and willingness to pay (WTP) for the new product attributes. Two types of techniques could be used: contingent valuation or choice experiment/experimental auctions methods.

The proxy index used for the new vaccine adoption in this study was the WTP. Data on WTP were obtained through individual interviews with men and women from cattle-owning households using the contingent valuation method (CVM) because of its simplicity and rapidity with which data can be collected. We interviewed the same group of respondents who attended the focus group discussions using a short individual questionnaire. The objective of the CVM study was to assess cattle owners' WTP for a new (hypothetical) CBPP vaccine being developed. Compared to the current vaccine, the new hypothetical vaccine has the following characteristics:

- Thermo-tolerant (not requiring refrigeration).
- Higher potency/efficacy.
- Needs only one round of vaccination/year instead of two rounds.
- No side effects on the vaccinated cattle (no abortion, sloughing off tissue at the vaccination site and no mortality).

These characteristics were clearly defined and explained to the respondents before the start of the contingent valuation exercise.

The contingent valuation method is a nonmarket valuation method widely used in the areas of environmental cost–benefit analysis and environmental impact assessment (Venkatachalam 2004). Carson and Hanemann (2005) provide a detailed description of the method from its initial development and theoretical background to its results' consistency with theoretical prediction. The method includes four major types of elicitation techniques: bidding game, payment card, open-ended question and dichotomous choice approach (Bateman et al. 2001; Venkatachalam 2004). In this study, researchers opted for the bidding game method.

In the bidding game method, respondents are asked a series of questions on their WTP for a specific item/product. In the current study, each individual respondent was asked if s/he was willing to pay[1] KSh 200 for the hypothetical CBPP vaccine/dose/year. If a respondent answered "yes", then s/he was asked for her/his WTP KSh 220, and so on. An increment of KSh 20 was made each time the participant responded "yes" until s/he responded with a "no". The last value that the respondent agreed to pay, before saying no, was documented as the respondent's stated value. If the respondent answered "no" to the first question on paying KSh 200, then the value was successively reduced by KSh 20 until the respondent said "yes". The first value that the responded agreed to pay, the value they said yes to first, was documented as the respondent's stated value.

The KSh 200 selling price of the new CBPP vaccine, used as the starting bid, was calculated by adding 30% to the estimated 1.5 USD cost given by one of the scientists involved in the laboratory development of the vaccines (Naessens, personal communication, 2014).[2] When implementing a bidding game elicitation format, the researchers are faced with two alternatives: using the same starting bid for all

[1] The US dollar was retailing at around Kenya shillings 87 at the time of the study (March 2014).

[2] USD 1.5 = Ksh 130.5. 30% of 130.5 = 39.15. 130.5 + 39.15 = 169.65—rounded off to Sh 200 to cater for currency fluctuation and vaccine delivery costs from source to end user in the study location.

respondents or choosing one starting bid randomly from among a list of different possible values. Literature review has revealed that some researchers found that the starting point had a sizeable influence on the final estimate of WTP (Rowe et al. 1980; Boyle et al. 1985), whereas other researchers found no such effects (Thayer 1981; Brookshire et al. 1982). In this study, the authors opted to use a unique value (KSh 200) for two reasons: first, a reasonable estimate of the production costs of the vaccine as well as reference prices for other cattle vaccines were available; and second, the item being valued (new CBPP vaccine) is well defined and distinctly perceived by the respondents.

The results were first analyzed using descriptive statistics whereby the mean, mode, minimum and maximum WTP for the vaccine from both men and women were obtained. In this first step, we used a midpoint estimation method where we considered the midpoint of the presented interval as the WTP value. Using Student's t test, statistical significance in the differences between both groups was sought. WTP is comprised in an interval, with lower and upper bands represented, respectively, by the last value that the respondent said "Yes" to and the first value that s/he said "No" to, for an ascending bid; or the first value the respondent said "Yes" to and the last value that s/he said "No" to for a descending bid.

In the next step, we estimated an interval regression model (Andersen et al. 2006) with the objective to assess the role of socioeconomic, geographic and cattle ownership variables in respondent's WTP. Following Wooldridge (2013, Sect. 17.4) the respondent's WTP is assumed to follow a linear function as below:

$$\mathrm{WTP}_i^* = \alpha + X_i\beta + \epsilon_i, \tag{1}$$

where WTP_i^* is the latent WTP value of respondent i, α the constant term, X_i a vector of explanatory variables, β the parameter vector associated with X_i, and ε_i the error term $\sim\ N(0, \sigma^2)$.

By standardizing each pair of lower internal threshold t_{li} and upper internal threshold t_{ui}, the probability that the true valuation of WTP lies between both thresholds can be given as in Shen (2012):

$$\Pr\left\{\mathrm{WTP}_i \in \left[t_{\mathrm{li}}, t_{\mathrm{ui}}\right)\right\} = \Pr\left\{\frac{t_{\mathrm{li}} - \alpha - X_i\beta}{\sigma} \le z_i \le \frac{t_{ui} - \alpha - X_i\beta}{\sigma}\right\}, \tag{2}$$

where z_i is the standard normal variable. The probability expressed in (2) can be written as the difference between two standard normal cumulative distribution functions and is expressed as:

$$\Pr\left\{\mathrm{WTP}_i \in \left[t_{\mathrm{li}}, t_{\mathrm{ui}}\right)\right\} = \boldsymbol{\Phi}(z_{\mathrm{ui}}) - \boldsymbol{\Phi}(z_{\mathrm{li}}). \tag{3}$$

Based on Eq. (3), the log-likelihood function is given as:

$$\log L = \sum_{i=1}^{N} \log[\boldsymbol{\Phi}(z_{\mathrm{ui}}) - \boldsymbol{\Phi}(z_{\mathrm{li}})]. \tag{4}$$

In the current study, the regression model was assumed to follow a linear function as follows:

$$\begin{aligned} \mathrm{WTP}_i^* = {} & \beta_0 + \beta_1\ \mathrm{Gender} + \beta_2\ \mathrm{Children} + \beta_3\ \mathrm{Adults} + \beta_4\ \ln\ \mathrm{Income} \\ & + \beta_5\ \mathrm{Joint} + \beta_6\ \mathrm{Alijarere} + \beta_7\ \mathrm{Bullaqalankala} \\ & + \beta_8\ \mathrm{Falama} + \beta_9\ \mathrm{Ruga} + \beta_{10}\ \mathrm{Sangole} + \varepsilon_i. \end{aligned} \tag{5}$$

WTP_i^* is the individual non-observable/latent willingness to pay; $\beta_k (k = 1, \ldots, 10)$ the parameter's coefficient to estimated; *Gender* is a dummy variable which takes 1 when the respondent is a male and 0 when it is a female; *Children* number of children in the household; *Adults* number of adults in the household; an adult is a person whose age is 18 years old or more during the survey period; *lnIncome* is the logarithm of the household income, which includes all income received by the household during the last 12 months, which includes farming (livestock, crops, etc.), off-farming, and other sources of income; *Joint* is a dummy variable which takes 1 when the cattle are jointly owned and 0 otherwise; *Alijarere* is a dummy variable which takes 1 when the household is in Alijarere and 0 otherwise; *Bullaqalankala* is a dummy variable which takes 1 when the household is in Bullaqalankala and 0 otherwise; *Falama* is a dummy variable which takes 1 when the household is in Falama and 0 otherwise; *Ruqha* is a dummy variable which takes 1 when the household is in Ruqha and 0 otherwise, *Sangole* is a dummy variable which takes 1 when the household is in Sangole and 0 otherwise; and ε_i is an error term assumed to be normally distributed with mean zero and standard deviation σ.

For the dependent variable (lower and upper interval levels), we used the logarithmic form. We estimated the model using the *intreg* command in STATA 14.

Individuals interviewed for the WTP study constituted the population of 12 sex-disaggregated focus group discussants of six men-only and six women-only groups (Table 1). Responses and explanations given during focus group discussions were deemed to be potentially complementary to the data obtained through individual interviews.

Results

In response to the questions on the status of CBPP vaccine delivery, opportunities and challenges of vaccine delivery were sought.

Opportunities for CBPP Vaccine Delivery

Livestock personnel and chiefs' accounts of proportion of the population dependent on cattle, 76 and 72%, respectively, and minimum number of cattle required for a household to trade in cattle, a mean of 175 cattle for both groups, were close (Table 2). The livestock personnel also indicated that 96% of the population vaccinates their cattle and 83% of the cattle are vaccinated against CBPP. The majority of animals not vaccinated were away in distant pastures or missed the last vaccination because they were less than 6 months old.

Table 2 Population characteristics and vaccination tendencies according to key informants

	Proportion (%) of population dependent on cattle	Minimum number of cattle required for a household to trade in livestock	Average number of cattle per household	Proportion (%) of human population that vaccinate against CBPP	Proportion (%) of cattle vaccinated against CBPP
Livestock personnel average	76	175	48	96	83
Livestock personnel range	40–100	20–500	15–100	80–100	75–100
Chiefs' averages	72.5	175	–	–	–
Chiefs' range	70–80	150–200	–	–	–

Using information obtained from community animal disease reporters and local leaders (chiefs), three main opportunities for excellent vaccine delivery exist. First, over 70% of the population depends on cattle as a livelihood source; second, 96% of the cattle-owning population vaccinate their animals; and finally, 83% of the cattle are already vaccinated. The current vaccine was retailing at KSh 15–20 (USD 0.17–0.23) per dose at the consumer end and KSh 6 (USD 0.07) at KEVEVAPI, which is the producer end. The difference in cost was the cost of transportation and the vaccinator's professional fee.

Constraints of CBPP Vaccine Delivery

Livestock personnel were asked what they considered to be the constraints to CBPP vaccine delivery. Most frequently mentioned constraints given by community animal disease reporter key informants are presented in an NVIVO word cloud. Poor impassable roads during the rainy season were mentioned most frequently followed by the need for vaccine refrigeration (Fig. 2). The key informant from KEVEVAPI associated poor vaccine delivery with two main challenges. First, needy customers

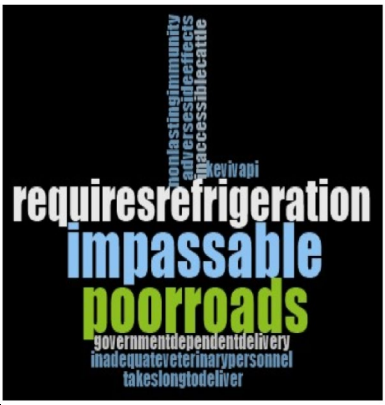
Field veterinary personnel KII word cloud	KEVEVAPI KII questionnaire responses
	**Q:** When does KEVEVAPI turn away CBPP vaccine buyers? **A:** *"When a buyer does not have the authority or a letter from the director of veterinary services (DVS) or the district veterinary officer (DVO) … because CBPP vaccination in the country is government controlled, is only allowed in some areas of the country and the use of the vaccine in every area must be with the knowledge of the DVS."* **Q:** When does KEVEVAPI experience challenges reaching buyers? **A:** *"Areas where the disease is a challenge and vaccination is allowed are very remote and with very few veterinarians on the ground. Farmers find it difficult to first locate the DVO and obtain a letter prior to purchasing the vaccine. KEVEVAPI is not allowed by government to sell CBPP vaccines to pharmacies or agrovet shops."* **Q.** How does KEVEVAPI deal with these challenges? **A:** "*As much as possible we encourage DVOs in allowed areas to stock the vaccine so that they can avail it to the farmers within short notice."*

Fig. 2 Constraints of delivery of CBPP vaccine given by livestock personnel key informants from the field and from KEVEVAPI

wanting to buy vaccine at KEVEVAPI were turned away in compliance with the government regulation that only veterinary personnel can purchase the vaccine. Second, and related to the first challenge, the vaccine consumers were not able to access the vaccine because there was a shortage of livestock personnel on the ground in CBPP endemic areas (Fig. 2).

Government control of CBPP vaccine delivery and shortage of veterinary personnel in areas where CBPP vaccination is allowed were identified by livestock personnel in the field as well as by the vaccine manufacturer. These two constraints in addition to the poor roads and the need for refrigeration of the vaccine contributed to poor vaccine delivery.

In Ijara, physical access to cattle because of poor and impassable roads was the most frequently mentioned constraint by the veterinarian and CADRs on the ground. This challenge is further compounded by the fact that the vaccine requires refrigeration. The vaccine is transported in vaccine carriers (small cool boxes packed with ice). The ice often melts during transport and is replenished in hospitals along the way. The vaccine being administered in the field during the time of data collection was still packed in ice, but the information on the label was not visible because it had become erased, probably because of frequent transfers to replenish ice packs (Fig. 3). One men-only discussion group mentioned that the vaccine label has often fallen off by the time the vaccine gets to them.

Policy-related challenges include the requirement that the vaccine be sold only to qualified veterinarians, and there is a shortage of qualified veterinarians on the ground. Some men-only group discussants, key informants and the KEVEVAPI respondent gave these two issues as major challenges to vaccine delivery. At the time of the study, March 2014, the Ijara veterinarian's position was vacant.

Responding to the question on the effect of gender on vaccine adoption, the following gender issues were investigated: the ratio of women and men in the community; differences in cattle wealth distribution between FHH and MHH and among individuals from these households; gender roles in cattle production; and the difference in WTP for a hypothetical CBPP vaccine between women and men livestock owners.

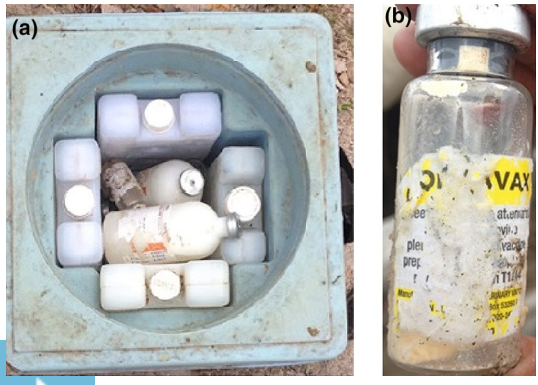


Fig. 3 **a** The vaccine and diluent in a bed of ice packs containing ice in a vaccine carrier, and **b** the unconstituted vaccine from the carrier in a vial with a worn-out label Photos by Mustafa Maalim Ahmed, March 2014

Ratio of Women and Men in the Community

The ratio of women to men in the population, obtained through proportion piling, was 59:41. Focus group discussants associated the deviation from close to the 50:50 national ratio (Index Mundi 2014) with more girls being born in the community, more women being brought in the community as brides because polygamy is commonly practiced, outmigration of boys and men to seek waged employment, and the fact that more men than women die in conflict.

Cattle Wealth Distribution by Gender Between and Within Male and Female Headed Households

Men and women FGD discussants agreed, during a proportion piling exercise, that households headed by men had more cattle wealth than those headed by women. The key informants, the CADRs and the chiefs gave a range of 3–100 head of cattle per household and about 40 head on average.

Within the households, and according to men and women FGD discussants (Fig. 4), cattle wealth distribution among men, women and children in a household is uneven, with women from MHH having the lowest proportion of cattle wealth. Women FGDs also indicated that 28% of the cattle belonging to FHH were owned by men. These men were not their children and the women were not asked who these men were. Men discussants also indicated that children owned most cattle (79%) belonging to FHH. According to men and women discussants, women own between

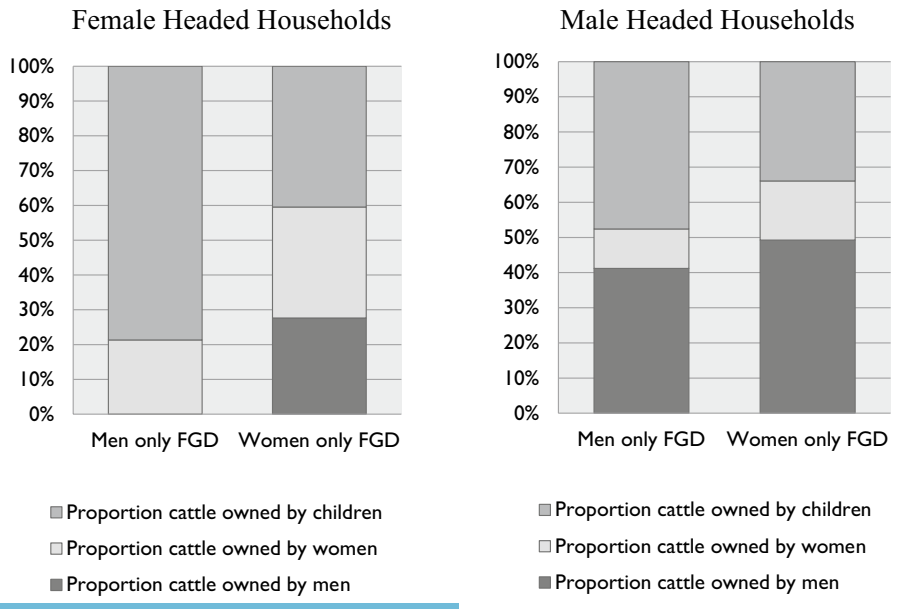


Fig. 4 Distribution of cattle ownership within male- and female-headed households

21 and 32% of the cattle in FHH, and between 11 and 17% of the cattle in MHH. Irrespective of the household headship, therefore, women own less than a third of the cattle wealth in the community.

The issue of joint cattle ownership in this community was investigated during group discussions to establish if men and women from the same households jointly owned cattle. Four out of six women groups and three out of six men groups agreed that there was no joint ownership, and whatever they termed jointly owned was tentative as demonstrated in the verbatim responses below, endorsed by focus group discussants.

"Even when you are told that they (cattle) belong to both of you, you soon realize that it is a situation of "nishikilie tu", which means "hold onto this one for me" … "Men are wealthier than women, so they own cattle because they bought them" … "Men own cattle, women access them but do not make decisions on them—men make the final decisions on the cattle" … "Man is the household head so he owns and decides on cattle." Women focus group participants, Ijara.

Joint ownership of cattle between spouses rarely occurs, and was reported to occur when, for example, a child died and his/her cattle were jointly held pending decisions on redistribution or disposal, and if a woman and man contributed money to buy cattle together. The data on cattle ownership are, therefore, unlikely to change because of joint ownership of cattle.

Results from the questionnaire interview with 137 respondents in this study indicated that 109 (80%) respondents owned cattle; 57% owned cattle as individuals, 2% jointly and 21% both individually and jointly. Of those who owned cattle jointly (2% and 21%), most owned them with their children (9%), then siblings (5%) and then with spouses (4%).

Cattle Related Gender Roles and Responsibilities and Time Spent Doing Them

Boys and men have specialized roles distinct from those for girls and women, but both genders share certain roles such as caring for sick animals (Fig. 5). Men spend 49% (11.76 h) of their time (24 h) doing cattle activities, whereas women spend 28% (6.72 h) of their time doing cattle activities (Fig. 5). Herding cattle in Ijara constitutes a large proportion of the time spent by boys and men, whereas milking constitutes a large proportion of time spent by women.

Owing to the exposure of men and women and boys and girls to cattle through different activities, men and women had different knowledge of cattle diseases. For example, because women interacted closely with individual cattle during milking, they could give more detailed clinical signs of CBPP than men (Fig. 6).

Vaccine Adoption and Willingness to Pay for Hypothetical CBPP Vaccine by Gender

A short face-to-face individual questionnaire was administered to the population of cattle-owning FGD discussants. A total of 137 respondents participated in the study.

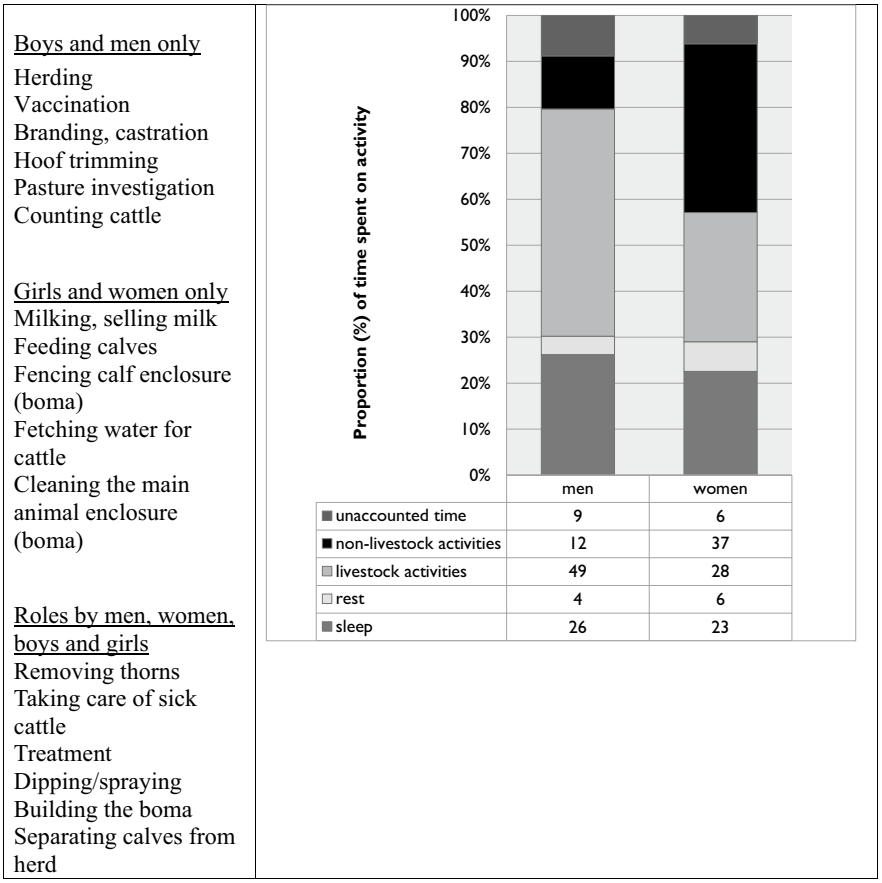


Fig. 5 Cattle-related roles by gender time spent on various activities on a 24-h day by gender

Fig. 6 Nvivo word clouds showing men and women's accounts of the clinical signs of CBPP

Table 3 Sample socio-demographic characteristics

Variable	Definition	
Sex (%)	Male	49
	Female	51
Marital status (%)	Single	3
	Married	87
	Widowed	1
	Divorced	9
Number of persons in the household	Mean	7.8
	Min./Median/Max./SD	2/8/15/2.7
Number of children in the Household	Mean	5.4
	Min./Median/Max/SD	0/5/13/2.6
Household income (KSh/year)	Mean	46,500
	Min./Median/Max./SD	1000/20,000/2,500,000/214,749
Individual cattle ownership (%)	Yes	77
	No	23
Joint cattle ownership (%)	Yes	23
	No	77

Min minimum, *Max* maximum, *SD* standard deviation

The results indicated that the sample was almost equally divided between men and women (Table 3). Most respondents were married and a few were divorced, with more women than men being divorced (more than three-quarters of divorced persons). Polygamy prevails in this community whereby men can marry more than one woman.

The average number of persons per household was eight. The standard deviation value indicated a low dispersion among the household sample. The average number of children per household was 5.4 with extreme values ranging between 0 and 13, but the standard deviation indicated a relatively low dispersion among the observations. The disparity in household annual income was huge among respondents and ranged between KSh 1000 to KSh 2.5 million, with an average annual income around KSh 47,000 and a median of Ksh 20,000. From the field observations during the interviews, the enumerators noticed that some livestock producers were underestimating their income because of the fear of taxation.

Respondents were also asked if they owned cattle individually. The results indicated that most (77%) had their own cattle. When disaggregating the results by respondents' gender, the proportion of men owning cattle individually (90%) was significantly higher ($p < 0.01$) than the proportion of women owning cattle individually (67%). The same applied to the number of cattle owned, where a man owned on average 20.8 while a woman owned on average 4.4 head of cattle, which was significantly different ($p < 0.01$). These results confirmed the disparity between gender groups in terms of cattle ownership and supported the results from the previous section on cattle wealth distribution by gender that indicated a higher number of cattle ownership by men than women.

Table 4 Cattle owners' WTP for CBPP vaccine (KSh/vaccine/animal/year)

Group	Mean	Mode	Minimum	Maximum	Standard deviation
Men ($n_1 = 58$)	245.0[a,*]	250	10	630	94.2
Women ($n_2 = 49$)	183.1*	170	50	450	86.9
All group	216.6[a]	230	10	630	95.7

*Statistically different at 1% level

[a]The two zero values were excluded from the analysis

Respondents were also asked if they jointly owned cattle with another family member. Around one-fifth of the participants responded positively. Surprisingly, this group was almost entirely composed of cattle owners who also owned cattle individually, except for the case of one woman who jointly owned ten cattle with her brother, but none individually. The rest of the respondents owned cattle jointly with their children mainly.

For the sake of the contingent valuation question and WTP assessment, we opted to only interview the persons who stated that they owned cattle individually or jointly with another family member. This decision was based on the assumption that persons who do not own cattle cannot provide a reliable response since the exercise would be hypothetical for them.

We dropped 28 persons from the initial group of 137 persons who did not individually or collectively own cattle (but belonged to households that owned cattle). Results from the 109 cattle owners' WTP are reported in Table 4. An analysis of the entire group of respondents (men and women groups together) indicated that cattle owners were willing to pay on average KSh 217/vaccine-dose/animal/year, which was slightly above the assessed production and marketing costs of the vaccine (KSh 200). The observations were moderately dispersed (coefficient of variation around 0.48), but with a few outliers. In fact, two male respondents stated that they will not pay any money for the vaccine, and one person declared willing to pay up to KSh 660. Many research studies have tried to "correct" for the zero-payment value, known as a protest response (Morrison et al. 2000). In this study, respondents after declaring their WTP were asked why they were willing to pay the specified amount. In the case of zero value respondents, one declared that he would never pay anything at any given time (which is a typical protest response), and the other declared that he did not have the necessary funds and that the amount (KSh 200) was expensive, which was also assumed to be a protest response. In the former case, we acknowledge the fact that the respondent may in fact have a genuine zero preference for payment for the new vaccine, but since the current vaccine is not delivered and administered free of charge, we decided to consider zero payment as a protest response.

When segmenting the sample by sex, the results differed between groups. Men were on average willing to pay KSh 245/dose/year, whereas women were willing to pay significantly ($p < 0.01$) less (KSh 183). Women were willing to pay 34% less than men. However, this midpoint estimation method relies on the supposition that

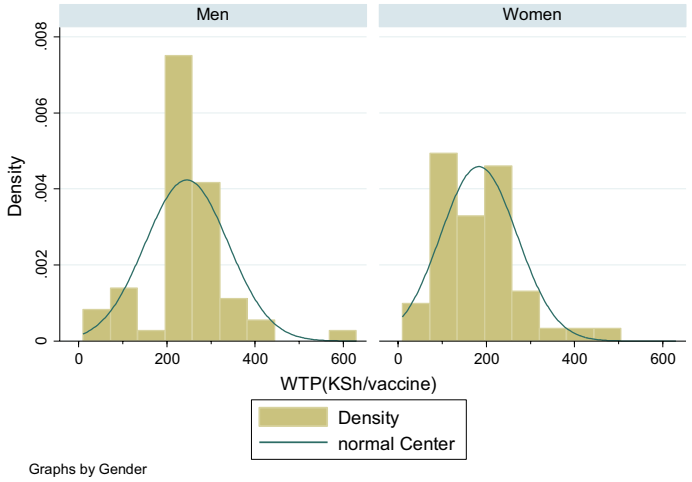


Fig. 7 Gendered cattle producers' WTP for CBPP vaccine using midpoint estimates

individual's expected WTP equals the midpoint of the presented interval (Shen 2012), which could lead to significant biases in the estimates if the assumption does not hold (Basu et al. 2003).

Density distributions of both men and women WTP are shown in Fig. 7. Men's WTP distribution is closer to a normal distribution, whereas for the women the distribution is closer to a bi-modal one with peaks at KSh 100 and KSh 220, which suggests the existence of two subgroups of women with different behavior/decision making or from different income brackets. Because of these reasons of possible bias, we estimated, in the second phase, an interval regression model, which relaxes the assumption of expected WTP to be equal to the midpoint of the interval. The WTP interval values were converted into a logarithmic form. We included a set of socio-demographic, location and animal ownership variables to explain respondents' WTP. The results are presented in Table 5.

The statistically significant value of the log-likelihood ratio test LR $\chi^2(10) = 36.36$ indicates the overall significance of the model, i.e., the model with variables is preferred to the model with only a constant. The results confirm that respondent's gender affects his/her WTP. The coefficient of the dummy variable "Gender" is positive and statistically significant ($p < 0.01$). It also indicates that men are on average willing to pay 28% more than women. The coefficients corresponding to the number of adults in the household and the number of children in the household are both positive but not statistically significant. In the case of the number of adults in the household, the positive sign was expected since we expect higher income and manpower from these households. The coefficient corresponding to the household income was not statistically significant and had a negative sign, which was not expected since we expected higher income households to be willing to pay more for the CBBP vaccine than lower income ones. In general, households with high income have higher numbers of cattle (we found a positive correlation), which represents a larger amount of money to be paid for vaccination. Respondents

Table 5 Interval regression coefficients' estimates of willingness to pay for improved CBPP vaccine

Variables	Coefficients	Standard error
Constant	4.222***	0.584
Gender	0.278**	0.110
Number of children in household	0.006	0.019
Number of adults in household	0.060	0.041
ln income	−0.003	0.055
Joint ownership	0.259**	0.111
Alijarere	0.831***	0.177
Bullaqalankala	0.815***	0.185
Falama	0.795***	0.188
Ruga	0.648***	0.175
Sangole	0.724***	0.175
Ln (σ)	−0.721***	0.069
σ	0.486***	0.033
Log-likelihood	−299.792	
LR χ_2 (10)	36.36***	
Prob > χ_2	0.0001	
Number of observations	107	

WTP interval levels are in logarithmic form

***,**Respectively significant at 1 and 5% levels

who owned cattle jointly with another person (generally from the same family) were willing to pay about 26% more than those not owning cattle jointly ($p < 0.05$). The ability to share costs could be the explanation for this result.

Finally, dummy variables were introduced to capture the possible effect of a respondent's location on his/her WTP for the improved vaccine. As earlier reported, the questionnaire was implemented in six locations. For the interval regression analysis, the Gedilun sublocation in the Sangailu location was selected as the base level. The results indicated that cattle owners form other sublocations are willing to pay much more than those from in Gedilun ($p < 0.001$). For instance, producers from Alijarere are willing to pay 83% more (highest premium) and those from Ruqa are willing to pay 65% more compared to those in Gedilun. Key informants and FGD discussants from Gedilun talked about two events of Rift Valley Fever occurring in the Sangailu location between November 2006 and April 2007 that left the population economically devastated as the disease depleted their cattle numbers. They are, therefore, still not able to afford the vaccine like the rest of the community.

From the model coefficients above, we estimated the mean WTP for the entire sample as well as for both groups of men and women. Mean WTP for the entire sample, men's groups and women's groups are, respectively, 191, 218 and 163 KSh/dose/year. These WTP values are lower and more robust compared to the ones assessed with the midpoint interval method (Table 4), but at the same time confirm the fact that men are willing to pay significantly ($p < 0.01$) higher prices than women to buy the new vaccine.

Discussion and Conclusions

The constraints to CBPP vaccine delivery to this community included poor roads that are impassable during the rainy season, the need for vaccine refrigeration, turning away of needy customers wanting to buy vaccine at KEVEVAPI in compliance with the government-controlled delivery of vaccine, and challenges of the vaccine reaching buyers with the shortage of livestock personnel on the ground in this CBPP endemic area. These challenges could occur in the Somali ecosystem of North-eastern Kenya (Isiolo, Wajir, Mandera, Marsabit, etc.), neighboring Somalia and Ethiopian Ogaden regions and possibly other high-temperature pastoral production areas prone to CBPP and with a similar social and religious structure, such as Burkina Faso, Niger and Mali. The policy recommendations made in this study might be applicable to these similar areas, but the limitations of this study in terms of sample size and sampling strategy could have compromised the sample's representativeness and the generalizability of these results beyond the study context.

Passable all-weather roads are necessary for any meaningful development to occur and should be a high priority of the county's development plan. The need to improve the road infrastructure is well acknowledged in Garissa county's development plan and estimated improvements noted (CIDP 2014); the following increase in the various components in the entire county include: bitumen roads from 21.5 to 200 km; gravel roads from 304 to 1000 km, for a total road network of 1804.5 km. The need for vaccine refrigeration may be overcome by the intended development of a thermotolerant CBPP vaccine. The issue of a shortage of veterinary personnel in the development plan is ambiguous, as the plan talks about increasing extension services without talking about increasing personnel (CIDP 2014). The requirement, by the government, that the vaccine be sold only to qualified veterinarians may cease to be relevant if a thermotolerant, safe and efficacious vaccine is developed.

Livestock personnel and chiefs' accounts of proportion of the population dependent on cattle, the minimum number of cattle required for a household to trade in cattle, the proportion of the population that vaccinates their cattle and the proportion of cattle vaccinated against CBPP indicate that the cattle owners are committed to control CBPP, and if the delivery of the vaccine was to be made highly efficient, it might be possible to eradicate CBPP through vaccination.

The ratio of 41:59 for men:women, documented in this study, deviates remarkably from the national ratio of 50:50 (Index Mundi 2014). Of the varying responses explaining this disparity, given by focus group discussants, the most logical explanation was that of outmigration by men and boys, and suggests that feminization of pastoralism might be happening in this community. Feminization of agriculture associated with rural to urban migration of men in search of waged labor is a well-established concept in smallholder agricultural communities (Deere 2005; Behera and Behera 2013) and pastoral communities (FAO 2012; Jothilakshmi et al. 2014). Feminization of pastoral communities, therefore, makes it crucial to involve women in livestock interventions because rural women will soon become the main cattle managers on the ground.

The finding that women own less cattle wealth than men has been reported before (Behera and Behera 2013; Njuki and Mburu 2013), and has been associated with the lower ability of women than men to adopt livestock technologies (Behera and Behera 2013; Mburu et al. 2013). This study adds to the knowledge on cattle ownership in this community by clarifying that the difference in cattle wealth ownership between women and men is highly significant; women from MHH own less cattle wealth than women from FHH, and joint ownership of cattle between men and their wives is rare.

In terms of gender roles and responsibilities over cattle in this community, men spend more time carrying out cattle-related activities than women. Men spend most of this time herding cattle whereas women spend the time milking and attending to cattle with newly born calves and those that are sick. Different gender roles in livestock (Saghir et al. 2012) and cattle (Johnson et al. 2013) activities have been documented elsewhere, with some roles being carried out exclusively by men, others by women and still others by women and men jointly. Because of the different gender roles, women and men are exposed to different aspects of cattle husbandry and are, therefore, likely to have different knowledge of cattle diseases and other cattle-related events, activities and outcomes. The fact that women knew of fewer diseases than men, but, for diseases known to them like CBPP, women knew more clinical signs and post-mortem lesions, suggests that women knew more depth and men more breadth about cattle diseases. Women and men's knowledge is, therefore, complementary. Reports of CBPP by women, based on detection of early signs, could be used to notify neighbors of the possibility of its occurrence so that communities can practice quarantine and notify others to ring-vaccinate around the affected herds to contain the disease.

The disparity in ownership of cattle wealth between men and women (the proportion of men owning cattle was significantly higher with men owning significantly more head of cattle than women) was reflected in men's and women's WTP values, whereby men were willing to pay significantly more money than women for vaccination of cattle against CBPP. That the gender of the respondent affects their WTP was demonstrated by the results from the interval regression model. The gender gap in access to resources and knowledge, whereby women have lower access than men, is well recognized. This stems from women's historical and cultural subordination, and is maintained through gender norms, roles, practices, beliefs, attitudes and discourses (Deere and Doss 2006; Doss et al. 2008; Deere et al. 2012; Quisumbing et al. 2013; Johnson et al. 2013). From the foregoing, unless interventions to enhance women's access to resources and knowledge are conducted, women are likely to continue adopting technologies like the CBPP vaccine at a lower rate than men.

Results also revealed that respondents owning cattle jointly with another person were willing to pay significantly more money than those not owning cattle jointly. An explanation for this difference is that the risk of illness or death of animals and the cost of vaccination is shared between co-owners. Joint ownership may, therefore, represent a person's inclination to risk aversion and may suggest that joint cattle owners are more likely to see the benefit of disease prevention by vaccination than those who own them individually.

The finding that respondents from Gedilun sublocation, Sangailu location, were willing to pay significantly ($p < 0.01$) less than those form other locations can be attributed to depleted herds of cattle during the Rift Valley Fever outbreak that occurred in Sangailu location between November 2006 and April 2007. The Sangailu cattle owners are, therefore, still not able to afford the vaccine like the rest of the community.

Results indicated that cattle owners are generally willing to pay a higher price for a new hypothetical thermotolerant and efficacious CBPP vaccine compared to what they are paying for the current vaccine (up to 10 times higher). A previous study by Kairu-Wanyoike et al. (2014) on CBPP vaccination in the Narok South District of Kenya revealed that cattle producers are willing to pay on average around KSh 212 per dose, which is close to the result of Ksh 191 in this research. Kairu-Wanyoike et al. (2014) used the conjoint analysis technique to assess farmers' WTP, whereas in this study we opted for the contingent valuation bidding game method. Although applied to cattle producers located in two different areas of Kenya, the mean WTP values derived from both methods were very close. This supports the results of both studies and the methods followed as well as demonstrating the similarity of cattle keepers in pastoral communities from CBPP endemic areas even from different geographical locations.

In developing countries, vaccine delivery in the market is often supply (push) rather than demand (pull) driven (Brooks et al. 1999), and most human and livestock vaccines are given free or sold at subsidized prices by government[3] and non-governmental organizations (Schelling et al. 2005). Enhancement of the vaccine safety and its thermo-tolerance should remove the necessity of government control. Government subsidy in the initial stages of the new vaccine introduction is likely to enhance the adoption rate by men and women cattle owners. Once the efficacy and safety of the vaccine are demonstrated, government subsidy can be gradually withdrawn as we expect cattle producers will have 'bought in' to the product.

The existing CBPP vaccine in the market is widely adopted, according to data on the proportion of people using it; the proportion of cattle already vaccinated and because the vaccine is affordable. Both women and men are aware of, and concerned about, the low vaccine efficacy requiring that cattle are vaccinated twice a year and the few cases of adverse post-vaccination reactions that may occur. Women were also concerned about the cost of the current vaccine. The data suggest that if a more efficacious and safer vaccine is developed it will be well received, but it must be affordable even by the women. A tiered vaccine subsidy strategy (Oyston and Robinson 2012) to accommodate cattle-poor pastoralists, many of who are women, is likely to enhance vaccine adoption by women.

Recognition and consideration of communities affected by unusual circumstances, like the effect of RVF on the vulnerability of the Gedilun community, calls for consideration for interventions that will address this vulnerability, such as subsidizing the cost of the vaccine to what the community can afford. The

[3] The Kenyan government provides free or subsidize cattle vaccination as a public good from time to time, especially during disease outbreaks.

tiered subsidy strategy can also be inclusive of communities adversely affected by catastrophes such as the RVF outbreaks in Gedilun.

The fact that the vaccine requires refrigeration makes the transportation process extremely cumbersome (ice pack replenishments, loss of labels and hence crucial information, etc.), which might compromise the already low efficacy of the vaccine. A thermotolerant vaccine is therefore crucial for this kind of environment. The poor road infrastructure has undermined the development of the study area and other similar areas. Unless the county government invests heavily in the road infrastructure, access will remain the greatest challenge to vaccine delivery and other development efforts.

Gendered division of cattle-associated roles and responsibilities has produced different and complementary types of knowledge on CBPP by women (clinical signs of the early disease) and men (signs associated with the latter stages of the disease as well as knowledge of more diseases than women). Recognition of this difference in knowledge and the utilization of all knowledge can contribute to prevention of spread of disease. A strategy whereby women alert the community when they detect early signs of disease leading to quarantine of suspect animals and herds, followed by ring vaccination of herds to contain the disease and prevent its spread, could prevent socioeconomic consequences of herd and trade losses associated with widespread CBPP outbreaks.

Feminization of pastoralism is ongoing in this community with a subsequent enhancement of women involvement in cattle production than before as men migrate from the communities in search of livelihood options. In spite of this, ownership of cattle by women remains low. Stakeholders in matters concerning livestock at the community levels need to recognize this transition in cattle management from men to women, and to engage women more than they did previously. Interventions like mobilizing women to work in groups and lobbying men to ensure inclusion of women participants in livestock development projects can ensure that women constitute a reasonable proportion (up to 60% in Ijara, which is commensurate with the current gender ratio) of beneficiaries of government and non-governmental interventions such as seminars and trainings on cattle production, health and trade.

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