Do more empowered women vaccinate more against East Coast Fever?
Evidence from lab-in-the-field experiment *

Aditi A Surve[a]

[a]School of Economic Sciences, Washington State University

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Abstract

This study investigates the impact of women's empowerment on individual well-being in livestock-dependent households, specifically focusing on East Coast Fever (ECF) management among women in Kenya. Utilizing a lab-in-field experiment based on the Women's Empowerment Livestock Index (WELI), the research examines how decision-making autonomy and control over livestock-related income influence vaccination decisions and economic outcomes. Participants are randomized into groups reflecting different levels of empowerment and then engage in a framed multi-stage game focused on vaccination decisions for hypothetical cattle. Results indicate that women who hold ownership rights to cows and the milk income they receive vaccinate more cows and achieve higher payoffs compared to those who control only milk income. These findings highlight the critical role of resource control in enhancing decision-making efficacy and economic well-being. The findings suggest that policies promoting joint ownership and income rights to empower women may improve livestock management practices and ensure economic stability.

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1 Introduction

The balance of power within a household is determined by the underlying distribution of ownership and control of assets (Quisumbing et al., 2003). When women are actively involved in household decision-making, it can enhance efficiency in resource allocation. Evidence suggests that women may prioritize child health and family well-being more prominently due to traditional caregiving roles, leading to distinct preferences (Dyson and Moore, 1983; Smith et al., 2003; Dasgupta, 2016). Additionally, research has shown that, on average, women may exhibit greater risk aversion (Powell and Ansic, 1997; Eckel and Grossman, 2008; Charness and Gneezy, 2012) and a stronger inclination toward future-oriented time preferences (Dittrich and Leipold, 2014).

The developmental economics literature suggests that empowering women improves their bargaining power and leads to a greater likelihood of investments being made in health, education, and nutrition that benefit the entire household (Thomas, 1990a; Beegle et al., 2001a; Duflo, 2003b; Doss, 2006; Deininger et al., 2013a; Menon et al., 2014). Decision-making within a household relies on the underlying distribution of ownership and control of assets (Doss et al., 2020). Assets can help mitigate liquidity constraints, diversify income, provide technology adoption, and improve individual and household well-being. As a result, studies have focused on reducing gender disparities in asset ownership, control, and access to enhance well-being.

In this study I conduct a lab in-field experiment in the context of livestock health technology adoption among women in Kenya. The primary objective is to estimate the causal impact of women's empowerment on individual well-being in adopting East Coast Fever (ECF) vaccines. I define empowerment based on two dimensions of the Women's Empowerment Livestock Index (WELI) (Galiè et al., 2019): (i) asset ownership and (ii) income generated from livestock production activities. Subjects participate in a multi-stage game using a customized app developed in Otree. They are randomly assigned into different groups based on whether they control cattle ownership (including rights over selling animals and revenue generated from the same), the income from milk sales, or both. The experiment progresses through two stages, comprising six rounds, effectively reproducing a decision-making process throughout the game. The two outcomes of interest are the number of animals they choose to vaccinate and the payoffs earned at the end of the game, which are a proxy for individual well-being.

While empirical studies focus on asset ownership and control using individual-level data, they face some challenges. Data related to ownership of the asset does not align with information identifying individuals possessing specific rights over that particular asset. This lack of alignment hinders the understanding of the relationships between ownership, rights, and potential variations among individuals (Kilic and Moylan, 2016). Moreover, previous studies have overlooked the extent to which different rights over assets impact outcomes. The circumstances under which ownership and control belong to the same person and how that impacts decisions are open questions (Doss et al., 2020). I conduct a novel lab-in-the-field experiment that addresses these issues in the context of understanding the relationship between women's empowerment and the adoption of the ECF vaccine.

ECF is a tick-borne disease that affects livestock, particularly cattle, causing economic constraints in East Africa (Norval et al., 1992). Vaccination is effective for preventing ECF, but its adoption among cattle keepers is often low, leading to continued outbreaks (Di Giulio et al., 2009). The choice of ECF management as the context is relevant because, in Kenya, most women control milk production from cattle but lack cattle ownership. Even when women own cattle, they often lack full ownership rights. Several studies have demonstrated that women are primary caregivers of cattle (Yisehak, 2008; Galiè et al., 2017; Miller, 2019; Jumba et al., 2020b). Thus, empowering women in livestock health decisions can benefit households and communities, as their unique perspectives and skills can contribute to disease prevention and overall livestock management. Notably, the combined control of cattle ownership and income flow may give women more influence over cattle health management and incentivize better strategies, including adopting vaccinations.

I find that participants with combined control of both ownership and income flow (Full rights) and those with control of ownership only (Partial ownership rights) vaccinate more compared to those who are in control of income flow only (Partial income rights). Intuitively, individuals with Full rights are the most empowered regarding autonomy and decision-making for their cattle, which translates into higher bargaining power. The greater autonomy associated with Full rights provides these individuals with better control over resources and a more substantial capacity to ensure the well-being of their livestock through timely vaccinations. This finding aligns with previous research highlighting the importance of comprehensive control over resources for effective decision-making and economic outcomes (Allendorf, 2007; Doss, 2013; Peterman et al., 2014).

Individuals with Full rights earn higher payoffs, whereas those with partial ownership rights earn less than those with Partial income rights. To examine the occurrence of this result, I look at the selling behaviors of the participants who have Full rights and Partial ownership rights. I find that participants with partial ownership control hold animals for extended periods resulting in negative payoffs. Intuitively, participants with ownership alone, without income from milk production, lack the necessary funds to manage ongoing expenses. Conversely, those with an income stream can hold their animals longer and manage resources more strategically, leading to positive payoffs. The income from milk production provides financial stability, allowing for a more measured approach despite the pressure from recurring costs. Thus, merely providing ownership does not improve economic payoffs and may even reduce them, indicating that full rights are crucial for maximizing both economic and health benefits.

This study adds to the existing literature in the following ways. First, it causally examines the impact of women's empowerment, as defined in the experiment, on individual well-being in the context of ECF vaccine adoption. In the context of agricultural interventions, several studies have used experimental methods to evaluate the impact of women's empowerment on well-being (Peterman et al., 2011; Capretti, 2023; Neer Somakka and Dwivedi, 2023; Fitawek, 2024). Additionally, several studies have demonstrated using experimental games to study asset ownership and decision-making (Munro, 2018). By leveraging the strengths of field experiments with real pay-offs, this experiment causally examines how decision-making influences the adoption of ITM vaccines for ECF. The causation is established by employing an innovative lab-in-the-field experiment to elicit preferences and overtly observing the decision-making process.

Secondly, this study provides causal estimates by uniquely defining empowerment based on two dimensions of the Women's Empowerment in Livestock Index (WELI), an index underutilized in past animal health management and adoption studies. The use of WELI has been rarely applied in past animal health management and adoption studies.Kaluwa et al. (2022b), examine the linkages between the empowerment of smallholder women farmers and their access to livestock vaccines in Machakos County, Kenya. Similarly, (Omondi et al., 2022) study the relationship between the empowerment of women farmers and their engagement with peste des petits ruminants (PPR) vaccination in Nothern Ghana. However, the existing studies correlate women's empowerment and livestock vaccination strategies. In contrast, I provide causal estimates to examine the relationship between women's empowerment and vaccination decisions in ECF. I specifically do that by employing a lab-in-the-field experiment and randomly varying the level of empowerment among individuals.

Lastly, this paper contributes to the literature on gender and the adoption of technology. Household bargaining power has a significant impact on agricultural production, too. It determines how resources like land and labor are allocated, who has access to credit and modern farming technologies, and who makes critical decisions about crop choices and income distribution (Udry, 1996; Sanginga, 2009; Fisher and Carr, 2015). For instance, Doss (2001) shows that women's bargaining power within households is crucial for adopting improved crop varieties and farming techniques in Ghana. Similarly, Quisumbing and Pandolfelli (2010) highlights that gender inequalities in access to resources and decision-making power hinder women's ability to adopt agricultural innovations. Emerick et al. (2013) explore the role of intra-household externality impedes technology adoption. Furthermore, a study by Peterman et al. (2014) demonstrates that empowering women with greater control over agricultural resources leads to higher adoption rates of new technologies and improved household welfare.

The literature on gender differences in the context of ECF and adoption of vaccine technologies is scarce (Surve et al., 2023). Jumba et al. (2020a) empirically examine the gender differences in access, demand, and adoption of ECF vaccine. Jumba et al. (2020b) investigate how both men and women perceive the effectiveness of the ITM vaccine and assess its influence on their respective livelihoods. However, existing studies have primarily focused on gender differences between men and women in ITM adoption against ECF (Jumba et al., 2020a,b). These studies have not yet examined the nuances of vaccine adoption within specific gender groups. This gap in the literature leaves unanswered questions about intra-gender variations in vaccine adoption behaviors and preferences, which could be critical for designing more effective and targeted intervention strategies. This study examines the impact of women's empowerment on cattle health management in the context of vaccine adoption and individual well-being by focusing on women and randomly varying the level of empowerment.

The remainder of the paper proceeds as follows: Section 2 provides the experimental design and conceptual framework. Section 3 describes the data, and Section 4 estimation strategy. In Section 5, I present the experimental results, heterogeneous treatment effect, and exploratory analysis. Section 6 provides a discussion and concludes.

2 Study Design

The study is based on data collected from a lab-in-the-field experiment I conducted in Narok, Kenya, from March 2024 to August 2024. The region of study is located in the southwest of Kenya and is dedicated to agro-pastoralism. Married women looking after cattle were selected as participants in the experiment. Subjects participate in a multi-stage game administered using a customized app developed in Otree. The experiment progresses through two stages and six rounds, simulating the vaccination decision-making process. Subjects are randomly assigned to different groups representing various empowerment. They receive clear and precise instructions, followed by comprehensive training sessions to prepare them for tasks related to calf vaccination, milk production, and potential animal sales during the game. At the end of the experiment, participants get paid based on their performance and decisions using real Kenyan Shillings.

2.1 Socioeconomic Context and Ownership Norms

Rural agricultural settings consist of female-headed households and women in male or joint-headed households. I mainly focus on the latter in this study, although a small percentage of the study sample consists of female-headed households. The challenges and opportunities in livestock farming differ for women smallholder farmers compared to men. This can impact individual empowerment, affecting food security, well-being, and livelihood (Galiè et al., 2019). In several countries, women are primary food producers and tend to control vital livestock products to produce the same (Njuki et al., 2013). According to Nelson et al. (2012), 70% of food producers and providers and poor livestock keepers consist of women. Kristjanson et al. (2010) observed that livestock raising is more accessible to women than growing crops. However, women tend to be owners of small ruminants as opposed to large livestock (Kaluwa et al., 2022a; Otiang et al., 2022).

Efforts to increase asset ownership rights among women in the livestock sector have been documented in various studies. Das et al. (2013) examined the BRAC's Challenging the Frontiers of Poverty Reduction program in Bangladesh, which transfers assets (primarily livestock) and provides training to rural women. The program significantly increased household asset ownership and impacted intrahousehold dynamics. Glass et al. (2014) evaluated the Pigs for Peace program in the Democratic Republic of Congo, finding that livestock asset transfer improved economic stability and health outcomes and reduced intimate partner violence in conflict-affected areas. Todd (1998) discussed microfinance programs like the Grameen Bank, showing how incremental investment in livestock helps women climb out of poverty by building their asset base and economic stability.

Livestock ownership, market participation, and access to information are often assessed at the household level, typically focusing on the head of the household, usually a man (Doss et al., 2011). However, this approach overlooks the intra-household dynamics and decision-making processes, particularly those involving women. Exceptions exist, notably in Asia (Quisumbing and De La Brière, 2000; Kumar and Quisumbing, 2010), but generally, data collection seldom targets other household members, especially women. Collecting data on intra-household resource allocation, income, and decision-making is complex but crucial. Individual-level data from both men and women is essential to understand gender relations, asset management, and income sources and to measure intra-household inequality across regions (Doss et al., 2011). However, this approach increases the complexity of data collection.

Currently, in Kenya, the majority of women typically only have control over milk production activities from cattle but lack ownership of the cattle themselves (See section 3.2 for more details). Although they own some cattle solely, they lack entirely ownership rights over those animals. With ownership, women may have more influence over broader livestock management strategies, including health interventions such as vaccination. Being in control of decisions about cattle ownership may provide an incentive to choose better management strategies. Given the motivation, this study is designed to uncover how autonomy and involvement in asset ownership and control decisions can impact well-being; Kenya presents an interesting setting to examine the dynamics of decision-making based on cattle ownership and control.

The US government's Feed the Future Initiative created the Women's Empowerment in Agriculture Index (WEAI) tool to measure the empowerment level of women in the agriculture sector. The survey-based index utilizes individual-level data from male and female household members through a dedicated household survey (Alkire et al., 2013). Studies in the past have used WEAI to examine the adoption of technology. Oyediran et al. (2023) investigate the economic impacts of improved melon seed shelling technology on women processors in Nigeria, highlighting the significant empowerment effects as captured by the WEAI. Similarly, Alam et al. (2024) examines how agricultural extension services and technology adoption mitigate production risks and influence women's empowerment, revealing notable disparities in WEAI scores in Bangladesh. Furthermore, Habtewold et al. (2023) provides evidence from rural Ethiopia, demonstrating how modern agricultural practices offer a pathway to women's empowerment by enhancing their agricultural roles and productivity.

However, only 30% of WEAI's questions are related to livestock. WELI was developed by researchers at the International Livestock Research Institute (ILRI) and Emory University to overcome this. WELI uses a set of questions related to livestock production and products and day-to-day decision autonomy about animal health, breeding, and feeding. The research defines empowerment based on WELI and uses a lab-in-the-field experiment to focus on controlling asset ownership decisions. This creates external variation and allows for analysis of its influence on decision-making. The index can be decomposed into various dimensions of empowerment. The index's decomposability helps us examine how the extent of rights related to asset decision-making can contribute to women's empowerment.

2.2 Study site, Sampling, Recruitment and Stratification

This study was approved by Kenya Medical Research Institute (KEMRI/SERU/CPHR/027/4314) in November 2021. The study was registered and a pre-analysis plan was submitted at AEA RCT registry.

Study site: The study was conducted in Narok County (See Figure 1), southwest Kenya. This location was chosen due to its high incidence of East Coast Fever (ECF) and malnutrition among children aged 6-59 months. The county has various livestock production systems, including pastoral, agro-pastoral, and sedentary mixed crop-livestock small holdings. These are crucial for understanding ECF's incidence, burden, and epidemiological impacts. Narok County covers an area of 17933 square kilometers and has an estimated population of 1,130,703 as of 2018.

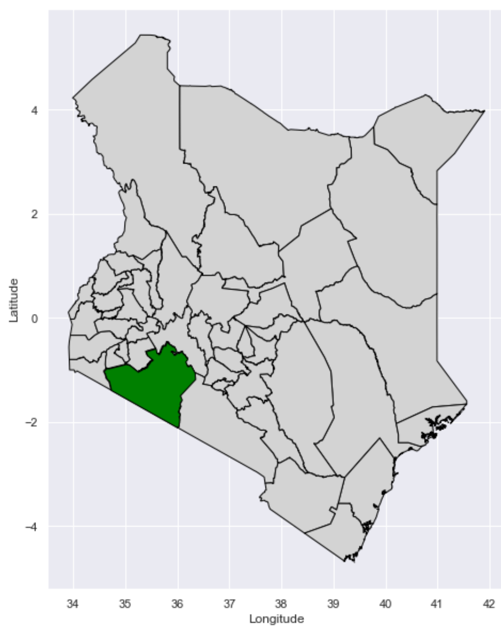

Figure 1: Map of Kenya highlighting Narok county

Sampling: The participants for this experiment are sampled from a larger study, Feed the Future Animal Health Innovation Lab (AHIL), funded by the USAID (Cooperative Agreement 7200AA20CA0002). The larger study focused on communities with high incidences of malnutrition and ECF, particularly those with different cattle production systems, including *i.* pastoralism: relying on low input costs and extensive land use, *ii.* intensive: high-input, high-output livestock production systems where cattle are raised in confined environments, *iii.* semi-intensive systems: a hybrid production system that incorporates elements of both extensive (pastoral) and intensive systems, and *iv.* mixed crop and livestock smallholder systems: small-scale farms integrating cattle and crop production. All eligible households in the selected villages were enrolled in the study after giving their consent. The study also included cattle as eligible domestic animals.

Recruitment: The following recruitment criteria were used to enroll participants for the experiment:

- Born female.
- Is married.
- Contributes to the management of her household's cattle.
- Provide informed consent to participate in the study.

Stratification:

Upon recruitment, participants were stratified based on baseline herd size and the gender of the household head. The rationale for stratifying based on gender is to capture potential differences in household dynamics and decision-making processes since the barriers and challenges in the adoption of the ECF vaccine are different between women and men (Jumba et al., 2020a). Herd size was chosen to stratify because it has been an important determinant in the adoption of ECF vaccines (Homewood et al., 2006; Karanja-Lumumba et al., 2015; Jumba et al., 2020a,b). Hence, depending on the baseline herd size, participants were divided into different quartiles. Within each quartile, participants were further divided into two groups based on the gender of the household head.

2.3 Randomization

Upon stratification, participants were randomly assigned to one of the three groups for the game, which indicated the level of empowerment as follows:

1. **Ownership and income**: Complete control over the purchase and sale of the animal (including the money spent or received)[1] and control over the milk produced by cows, how it is used, or money received from its sale.[2]

[1] Complete control of the money that is generated from the sale of cattle; also in charge of cattle activities related to purchase, giving away as a gift, using the cattle as collateral.

[2] Complete control of what to do with the money generated from selling products, here milk, obtained from cattle.

2. **Income only**: Complete control over the milk produced by calves, how it is used, and money received from its sale, but no control over the purchase and sale of the animal or the money spent on the purchase or received from the sale.

3. **Ownership only**: No control over the milk produced by calves, how it is used, and money received from its sale, but complete control over the purchase and sale of the animal or the money spent on the purchase or received from the sale.

Each participant is asked to play the game twice. However, once a participant is assigned an empowerment status, it remains the same for the entirety of that particular game.

2.4 Game design

Subjects engage in an interactive game where they perform several tasks through a computer application developed through Otree Chen et al. (2016). Each subject goes through an experiment session consisting of the following steps: (i) registration through consent of the participant, (ii) explanation of the background of the problem of ECF, (iii) discussion of the structure and details of the game, (iv) detailed explanation and training on how the game would appear on the Otree user interface, (v) conduct the experiment, (vi) short exit survey post experiment and, (vii) payments to participants.

Subjects play the game twice. The status of empowerment changes between the two games but remains the same within each game. Table 1 illustrates the parameters used for constructing payoffs in the game. Note that the parameters were calibrated based on the baseline data, which is part of the bigger AHIL survey (See Appendix Table 11 for more information).

The experiment takes place in two stages. Before the exercise begins, participants get an endowment, End_t of 100 points, and a herd of 10 calves in the age group of 3 - 9 months [3]. Participants receive a participation payment and the opportunity to earn real money up to USD 5 to promote active engagement and truthfully reveling their preferences during participation.

Stage one consists of one round called the base year. In stage one, all participants are asked the number of calves they would like to vaccinate V_t. Participants can use their endowment of 100 points to vaccinate their calves [4]. Thus, the number of non-vaccinated calves is N_t = 10 - V_t. Suppose participants belong to the group that controls ownership of assets. In that case, they are

[3]This is when calves are eligible to receive vaccine against ECF

[4]Note that endowment is enough to vaccinate all cows.

Variable	**Key**
End_t	Endowment
Exp_t	Expenditure
F	per calf Vaccination fixed cost
M_t	Maintenance cost
S	Sickness cost
p_t	risk of a non-vaccinated animal getting sick
V_t	Number of vaccinated animals
N_t	Number of non - vaccinated animals
SV_t	Number of vaccinated animals sold
SN_t	Number of non - vaccinated animals sold
P	Market price per liter of milk
P_{sv}	Market price (per animal) of selling a vaccinated animal
P_{nv}	Market price (per animal) of selling a non-vaccinated animal
q	Milk output in liters per animal

Table 1: Key for variables

asked to perform an additional task: determine the number of vaccinated (VS_t) and non-vaccinated (NS_t) calves they would like to sell.

Stage two consists of 5 rounds. Hence, combining stages one and two, there are six rounds. Stage two takes place three years after stage one. This assumption accounts for young calves maturing in old animals such that they are eligible to produce milk. Each round in stage two (from rounds 2 to 6) is assumed to be three months apart to realize the gains from the income stream through the sale of milk production.

Based on the decisions the participants make and associated parameters in each round, they receive payoffs referred to as earnings. The parameters for the payoffs are calibrated using real-life data. The points that participants earn in round t will be the starting endowment in round $t + 1$. Examining the overall payoffs among women provides valuable insights into the broader welfare implications of gender-inclusive asset distribution. Ownership can empower women economically, granting them greater autonomy, decision-making power, and financial security. Thus, analyzing the overall payoffs is essential to understanding its potential to reduce gender inequality and promote inclusive development, reinforcing why policies supporting women's ownership can be pivotal for long-term welfare improvements.

There are some costs that participants may incur in each round. Participants face a predetermined set of expenses Exp_t in both stages, irrespective of group assignment, which includes all expenses unrelated to ECF. During each stage, they incur a maintenance cost of M_t to account for other management strategies, particularly the application of acaricides to safeguard the animals from

ECF. If an animal gets vaccinated in round 1, the maintenance cost in periods starting from round $t+1$ drops by a third, $\frac{M_t}{3}$ [5].

All participants incur a per unit vaccination cost in round 1 of the exercise, F. Participants then receive a randomly generated probability of a non-vaccinated animal getting infected in a particular round, p_t. Thus, based on the underlying risk of infection, a non-vaccinated animal might get infected in a specific round and, in some cases, even die due to ECF. It is also assumed that a vaccinated animal cannot fall sick due to ECF. Assuming that the per animal sickness cost is S, the total expected sickness cost of a non-vaccinated animal at time t is :

$$S \cdot p_t \cdot N_t \tag{1}$$

The expected sickness cost of a cow at time t takes into account the cost of maintaining a sick cow (S in Equation 1) and the expected number of sick cows at time t, which is the probability of an animal getting sick (p_t) and the total number of non-vaccinated cows in Equation 1).

Some participants can also accumulate points through milk production. Income can be generated by selling the milk produced starting for rounds in the second stage. The price per liter of milk is given and assumed to be P [6]. Assuming that q is the milk output produced by a cow, the total expected revenue generated from milk production in each round is:

$$[V_t \cdot q + N_t \cdot (1 - p_t) \cdot q] \cdot P$$

$$= [V_t \cdot q + N_t \cdot q - N_t \cdot p_t \cdot q] \cdot P \tag{2}$$

Thus, the expected milk revenue is considered for the sum of the total milk generated by vaccinated and non-vaccinated cows minus the expected decline in the milk produced by non-vaccinated cows due to ECF times the price per liter of milk.

Subjects with ownership control can also earn from selling animals (both vaccinated and unvaccinated). The market price for selling a vaccinated and unvaccinated animal is assumed to be P_{sv} and P_{nv} respectively.

[5] An advantage of using ITM is the potential to minimize the use of acaricides, leading to cost savings. Moreover, decreasing acaricide use may increase cattle infection with ECF, ultimately strengthening immunity after ITM (Kivaria, 2006; Lynen et al., 2012; Tenesi, 2015)

[6] Farmers in Kenya selling milk do not control prices. Hence, prices are given.

Thus, the expected revenue generated from selling animals at time t is given by:

$$SV_t \cdot P_{sv} + NV_t \cdot P_{nv} \tag{3}$$

The above Eq 3 considers the total number of vaccinated and non-vaccinated cows the participant decides to sell times the market price. Note a vaccinated animal in a market place is identified with an ear-tag and commands higher price than a non-vaccinated animal. Hence in the above equation $P_{sv} > P_{nv}$.

Assuming that the discount factor is δ, the total payoffs are payoff from stage one and discounted payoff from stage 2 and are given as follows:

Stage one, round one

$$Payoffs = 100 - Exp_t - [V_t \cdot F + M_t \cdot N_t + S \cdot p \cdot N_t]$$

$$+(1 - \tau_o)(SV_t \cdot P_{sv} + NV_t \cdot P_{nv})$$

Stage two, round 2 - round 6

$$Payoffs = End_{t-1} - Exp_t + [-(M_t/3) \cdot V_t - M_t \cdot N_t - S \cdot p_t \cdot N_t]$$

$$+(1 - \tau_f)(\sum_{t=2}^{6} P \cdot H_t \cdot q) + (1 - \tau_o)\sum_{t=2}^{6}(SV_t \cdot P_{sv} + NV_t \cdot P_{nv})$$

Optimal Behavior

- Ownership and income $\tau_o = 0, \tau_f = 0$: complete ownership of assets and complete control over the flow of income
  - Vaccinate all calves and sell all cows in the last round of a particular game. Selling all the cows in the last round of the game is optimal in this case since participants would receive revenue from milk production in earlier rounds.
- Income flow only $\tau_o = 1, \tau_f = 0$: no ownership of assets and complete control over the flow of income
  - Vaccinate all calves.

- Ownership only $\tau_o = 0, \tau_f = 1$: ownership of assets and no complete control over the flow of income
  - Vaccinate all calves and sell all cows in the second round of a particular game. Selling all the cows in the second round of the game is optimal in this case since participants would not have to incur additional costs such as per-animal maintenance costs. If they choose to hold animals beyond round 2, then they are incurring maintenance costs, which could have been avoided otherwise.

The following figures show an example of what the Otree interface looked like for the participants. Figure 2 shows the vaccination page that appears for all participants. Figure 3 shows an example of the selling decision page which appears only for participants with ownership rights.

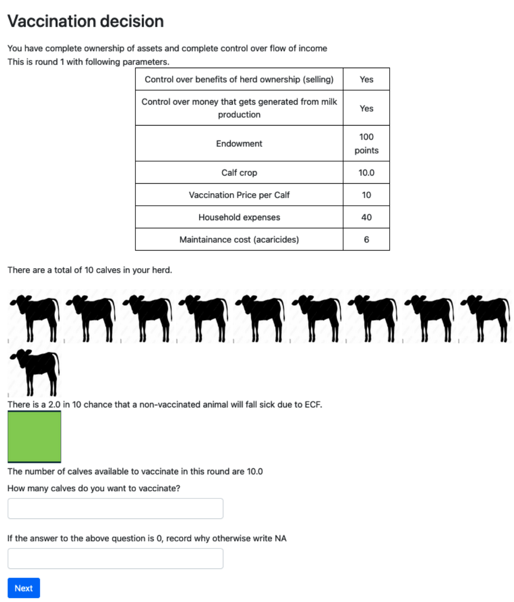

Figure 2: Vaccination decision page.

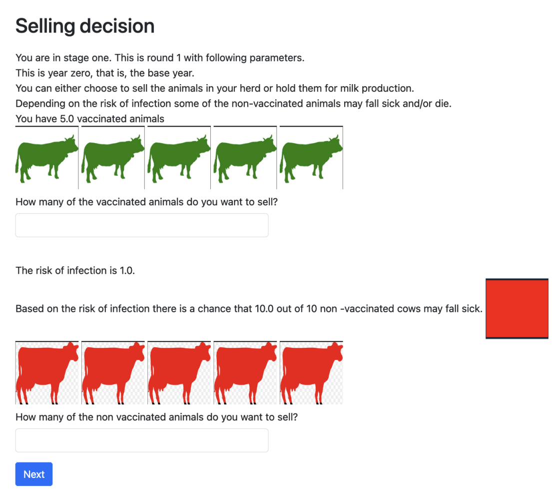

Figure 3: Selling decision page.

Two modifications were made in the Otree game throughout the data collection [7]. The data using the original version of the Otree game was collected from 214 participants. The first modification was implemented in May 2024 where participants would incur a randomly generated high or a low maintenance/acaricides cost. This modification was introduced to examine the participant's response to vaccination choices in the presence of an alternative management strategy. The second

[7]Note that fixed effects are included to control for the changes.

modification was introduced in June 2024, particularly for participants with ownership control. The enumerators for participants in groups with ownership control would remind them in the last round that the value of any unsold animals will not be accounted for in the points they earn at the end of the game.

3 Data

The data for this study were obtained from a cross-sectional survey carried out in the southwest of Kenya. The sample population includes married women engaged in day-to-day livestock activities, particularly related to cattle from Narok County, Kenya. The enumerators collected the data using Android mobile devices. The pilot took place in February 2024, and broader data collection was launched in March 2024. The data collection concluded in July 2024. The data are individual-level and consist of comprehension checks, variables from the Otree game, and baseline characteristics. The comprehension checks and baseline characteristics each consisted of one data point. However, each participant was made to play the game twice, so the variables for the Otree game consisted of two sets of observations from each participant, from Game One and Game Two.

3.1 Baseline Characteristics

This section provides summary statistics on the baseline characteristics of the sample population, comprising 602 subjects. The average age of the participants is 38.52 years, with a wide dispersion indicated by a standard deviation of 11.98. Majority of the study participants almost 54% have no education, followed by Primary but not completed with 0.15%.

The summary statistics indicate a notable difference between the number of cattle owned solely by subjects and the total number owned by their households. On average, participants report owning 3.25 cattle solely, with a standard deviation of 9.02, suggesting considerable variability among individual ownership levels. However, the median is 0. In contrast, the median number of cattle owned by households is 10. A mean of 17.44 and a high standard deviation of 22.87 indicates substantial variability in the number of animals owned, as some households possess significantly more animals, thus raising the average.

This disparity highlights that individual participants tend to have much less sole ownership of livestock than collective ownership within the household. Given the lower frequency of sole ownership, participants may have limited autonomy in managing, selling, or using livestock for financial purposes without household consensus, which is further reflected in Table 2. This dynamic can affect the effectiveness of interventions to empower individuals, particularly women, in the livestock sector.

Regarding the ability to manage the cattle they own solely, ownership rights, only about 17% of subjects have the ability to give cattle as a gift. None of the participants reported the ability to sell cattle, reflecting uniform constraints, possibly due to cultural, legal, or economic factors. Similarly, only about 13% of participants have the ability to loan cattle, highlighting limited capacity for lending practices involving cattle.

Variable	Count	Mean/ Proportion	Std	Min	Median
Age	602	38.52	11.98	21	38
Education: None	602	0.54	0.49	0	1
Education: Pre-school	602	0.03	0.16	0	0
Education: Primary	602	0.09	0.29	0	0
Education: Primary(not complete)	602	0.15	0.36	0	0
Education: Secondary	602	0.07	0.26	0	0
Education: Secondary(not complete)	602	0.06	0.24	0	0
Education: Tertiary	602	0.03	0.17	0	0
Education: Tertiary(not complete)	602	0.01	0.09	0	0
Cattle owned in total by household	602	17.44	22.87	0	10
Cattle owned solely	602	3.25	9.02	0	0
Right to give cattle as gift	602	0.17	0.38	0	0
Right to sell cattle	602	0	0	0	0
Right to loan cattle	602	0.13	0.33	0	0
Right to pledge cattle as collateral	602	0.11	0.32	0	0
Right to slaughter cattle	602	0.09	0.40	0	0

Table 2: Baseline characteristics

Based on the summary statistics, the majority of the women lack ownership of cattle. Despite owning some cattle solely, they lack full ownership rights, which hinders decision-making and resource allocation. Hence, using this as motivation, this study aims to examine how autonomy in cattle asset ownership impacts well-being, using a lab-in-the-field experiment to create variation in ownership control. By focusing on decision autonomy as defined by the WELI, the study aims to understand the effects of women's involvement in livestock management strategies, including health interventions like vaccination.

3.2 Comprehension Checks

Likelihood of ECF illness: As mentioned in the game design, participants are given a random chance (p_t) of a non-vaccinated animal getting infected in each round. Depending on this risk, a non-vaccinated animal might get infected or even die from ECF. Hence, much time was spent ensuring that participants understood the chance or likelihood of a certain event.

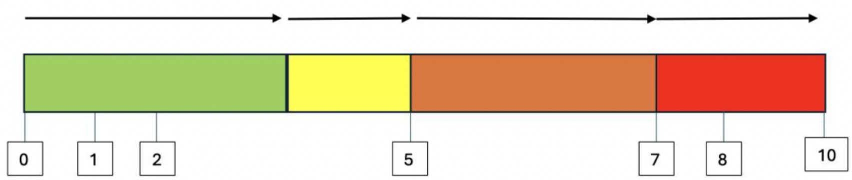

Figure 4: Probability scale

Figure 4 shows the probability scale that was used to to explain the chance of a particular event happening. The scale represents one chance out of 10, increasing from left to right. Due to educational constraints among the study population, visual cues were used for understanding. The risk of infection in the actual game was also color-coded, similar to the scale in the above figure, for consistency. Comprehension checks were conducted following the explanation of the probability scale. Table 3 shows the summary statistics from the comprehension checks.

Variable	Count	Mean/ Proportion	Std	Min	Max
Visit days	602	2.33	1.42	1	5
Visit weeks	602	3.04	1.13	1	5
ECF no outbreak	602	3.25	0.93	1	5
ECF outbreak	602	1.73	1.42	1	5
Visit check	602	0.87	0.33	0	1
ECF outbreak check	602	0.90	0.29	0	1

Note: Visit days and Visit weeks are variables asking the participants the likelihood of visiting their friends/neighbor/family at least once in the next two days and two weeks, respectively. ECF no outbreak and ECF outbreak denote the participant's responses to the likelihood of an unvaccinated calf becoming infected and dying from ECF in outbreak versus no outbreak scenarios. Visit check is a dummy variable equal to 1 if Visit days $\leq$ Visit weeks. ECF outbreak check is a dummy variable equal to 1 if ECF no outbreak $\geq$ ECF outbreak.

Table 3: Comprehension Checks summary statistics

The first check was related to scenarios based on everyday life. Particularly, the participants were asked how likely they would visit a friend/neighbor/relative at least once in the next two days versus two weeks, indicated by variables Visit days and Visit weeks, respectively. Both variables were coded using a Likert scale ranging from 1 to 5, with 1 indicating least likely. The comprehension check is recorded by Visit check, which is a dummy variable equal to one if Visit days are less than or equal to Visit weeks. The "Visit check" revealed that 87% of the participants correctly comprehended that it's more likely that they would visit someone within two weeks rather than within two days, indicating that they understood the concept of probability.

During the next check, participants were questioned about the likelihood of unvaccinated calves, aged 3-9 months, becoming infected and dying from ECF during an outbreak in their community. This was represented by the variables ECF outbreak and ECF no outbreak. Similar to the previous check, a Likert scale was used to measure the participants' responses, and the ECF outbreak check was recorded as a dummy variable, with a value of one if ECF no outbreak was greater than or equal to ECF outbreak. According to the statistics, 90% of the participants grasped that during an outbreak, unvaccinated calves face an increased risk of infection due to exposure to ticks carrying the illness.

3.3 Outcome variables

The summary statistics in Table 4 provide an overview of key outcome variables across two games. First, looking at the number of calves vaccinated, the mean number of calves vaccinated in Game One is 9.17, while in Game Two, it is slightly lower, at 9.09. Both games show a similar distribution, with a minimum of 0 and a maximum of 10 vaccinated calves, indicating that participants generally chose to vaccinate almost their entire herd in both games. Payoffs, measured as points earned by the end of each game, show more variation. The mean payoff in Game One is 1808.06 points, while in Game Two, the mean payoff is slightly lower at 1746.13 points.

Variable	Count	Mean	Std	Min	Max
Calves vaccinated in Game one	602	9.17	1.80	0	10
Calves vaccinated in Game two	602	9.09	1.96	0	10
Payoffs in Game one	602	1808.06	471.38	-44	2865
Payoffs in Game two	602	1746.13	473.37	-255	2690

Note: Calves vaccinated in Games One and Two refers to the number of calves chosen by participants in the first round of the game. Payoffs refer to the points earned at the end of each game.

Table 4: Outcome variables summary statistics

4 Estimation strategy and identification

I study the effect of women's empowerment on two outcomes. The dependent variable for vaccine decision is the number of calves the participants choose to vaccinate in round one. The payoffs earned by each participant at the end of each game, that is, in round six, are used as the outcome to measure individual well-being. Following regression equations were used to estimate the outcomes.

$$Cowsvaccinate_{ig} = \beta_0 + \beta_1 Ownership\&Income_{ig} + \beta_2 OwnershipOnly_{ig} + \beta_3 X_{ig} + e_i \tag{4}$$

$$Payoffs_{ig} = \beta_0 + \beta_1 Ownership\&Income_{ig} + \beta_2 OwnershipOnly_{ig} + \beta_3 X_{ig} + e_i \tag{5}$$

$Ownership\_and\_income_{ig}$ and $Ownership\_only_{ig}$ are indicator variables equal to 1 if participant i is assigned to that particular Group in game g. The variables of interest, β_1 and β_2, measure the impact of empowerment on the outcome compared to the status quo, that is, participants who have control over income flow only. X_{ig} is the vector of individual-level characteristics [8] and also includes stratum fixed effects [9]. Standard errors are clustered at the individual level. ϵ_i is the Individual error term.

5 Results

5.1 Impact of empowerment on vaccination and individual well-being

This section examines the Average Treatment Effect (ATE) of empowerment on the outcomes of interest. The analysis shows results from Game One and Game Two. Table 5 presents the ATE for Game One and Game Two, evaluating the relationships between various factors and the dependent variables: vaccine decision and payoffs.

In Game One, the impact of control over ownership and income on vaccine decision-making is positive, indicated by the parameter estimate of 0.012. However, the result is statistically insignificant, suggesting that, in Game One, complete control does not significantly influence vaccine decision-making. In the case of ownership only, the result is statistically significant effect at 10%

[8] The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant and Individual fixed effects

[9] Participants are stratified based on baseline herd size and gender of the household head(See section 2.2).

	(Game 1) Vaccine decision	(Game 2) Vaccine decision	(Game 1) Payoffs	(Game 2) Payoffs
Ownership and income	0.012	0.624***	292.6***	358.6***
	(0.179)	(0.222)	(36.292)	(47.364)
Ownership only	-0.329*	0.748***	-460.0***	-249.8***
	(0.191)	(0.205)	(35.973)	(46.850)
Controls	Yes	Yes	Yes	Yes
Stratum FE	Yes	Yes	Yes	Yes
Income only Mean	9.323	8.668	1849.7	1718.9
Observations	602	602	602	602

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Whereas the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are an indicator variables determining whether subjects are assigned in that particular group. Stratum FE are fixed effects refer to the strata the participant belongs to in the experiment. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 5: OLS Results

level with a co-efficient of -0.329. In contrast to Game One, the results in Game Two are positive and statistically significant, especially in the ownership and income group. In Game Two, when individuals have control over ownership and income, there is an average increase of 0.624 cows vaccinated in the herd compared to those with control over income only. Furthermore, the effect of ownership alone on vaccination decisions in Game 2 is also positive and significant. The coefficient is significant at the 1% level, indicating that even without the influence of income, ownership alone significantly boosts vaccination by 0.784 cows. The difference in vaccination between participants in ownership and income and ownership only is not statistically significant from each other in Game Two, with a p-value of 0.36.

In the case of payoffs, a measure of individual well-being, for the participants representing control over both ownership and income, the coefficients are consistently positive and statistically significant at 1% level: 292.6 in Game 1 and 358.6 in Game 2. As observed in the case of vaccine decisions, participants with control over ownership and income flow vaccinate the most and, as a result, experience a significant increase in payoffs. Conversely, the effect of ownership alone on payoffs is significantly negative across both games: -460.0 for Game 1 and -249.8 for Game 2. This indicates that individuals with only ownership, without accompanying income control, see a substantial payoff decrease. Additionally, like the vaccine decisions, the magnitude of coefficients in Game Two, for participants in both groups, are higher compared to Game One.

The pooled regression analysis shows that the coefficient for control over ownership and income is 0.273, significant at the 5% (See appendix Table 12). In the case of payoffs, results indicate that participants with both ownership and income have a positive and significant effect on both vaccine decisions and payoffs, while ownership alone has a positive effect on vaccine decisions but a negative effect on payoffs (See appendix Table 12).

To further investigate the payoff outcomes, I conducted an additional analysis to assess whether participants behaved optimally in the game, constructing a new outcome variable termed *Normalized Payoffs* [10]. This measure was created by first calculating the maximum possible payoffs each participant could achieve within their respective group. I then computed the ratio of actual earnings to this optimal maximum, reflecting the degree of payoff maximization. Table 6 presents the regression results assessing the impact of empowerment on *Normalized Payoffs*.

	(Game 1) Normalized Payoffs	(Game 2) Normalized Payoffs
Ownership and income	-0.408***	-0.356***
	(0.014)	(0.020)
Ownership only	-0.224***	-0.119***
	(0.017)	(0.023)
Controls	Yes	Yes
Stratum FE	Yes	Yes
Observations	602	602

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Whereas the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are an indicator variables determining whether subjects are assigned in that particular group. Stratum FE are fixed effects refer to the strata the participant belongs to in the experiment. *p<0.1; **p<0.05; ***p<0.01

Table 6: OLS Results for Normalized Payoffs.

In both games, participants in the Ownership and income group earned significantly lower *Normalized Payoffs* (coefficients: -0.408 for Game 1 and -0.356 for Game 2, both significant at the 1% level) relative to the Income only group. This suggests that despite having ownership and

[10]Note: This analysis was not pre-specified.

income, these participants underperformed relative to the potential maximum payoffs, indicating sub-optimal decision-making. Similarly, participants in the Ownership only group also demonstrate significantly lower *Normalized Payoffs* (coefficients: -0.224 for Game 1 and -0.119 for Game 2, both significant at the 1% level).

Overall, the results underscore the importance of comprehensive empowerment, combining ownership and income, to achieve positive economic results. While ownership and income significantly enhance payoffs, ownership alone can lead to lower payoffs, highlighting the need for policies that ensure asset control and income support for improved economic well-being. Thus, the results suggest that giving women ownership rights may increase vaccination and well-being. However, the results also indicate that participants in the Ownership and income group and Ownership only behaved sub-optimally in both Games. The results in case of *Normalized Payoffs*, may be influenced by the fact that, in reality, these participants may not typically own cows and, therefore, may lack familiarity with optimal decision-making regarding the timing of sales. This lack of practical experience could contribute to the observed sub-optimal behavior, as reflected in the lower Normalized Payoffs across both games. The selling behaviors of participants in different groups may explain the result in the case of the *Normalized Payoffs*. The next section of the analysis delves deeper into this relationship by examining the participants' selling behavior within the game.

5.2 Sales trend analysis

This section explores how different levels of control over ownership and income influence participants' strategies and decision-making processes. The section aims to provide a more detailed understanding of the mechanisms behind the observed effects on payoffs by analyzing specific patterns and behaviors. Figure 5 illustrates the average sales, that is, the number of cows sold on average by each participant, trends across six rounds from Game One, for participants in different treatments: ownership Only and ownership and Income. Similarly, Figure 6 shows the average proportionate sales relative to the herd size in a given round.

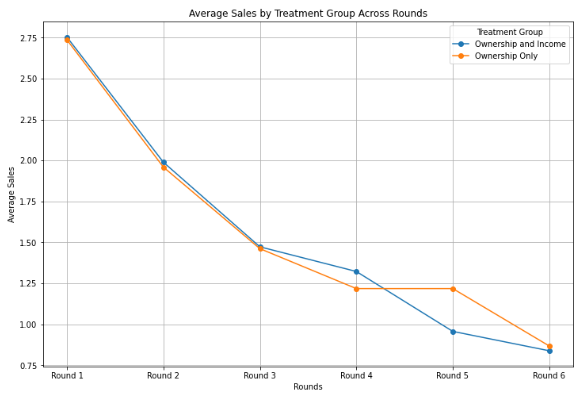

Figure 5: Average sales.

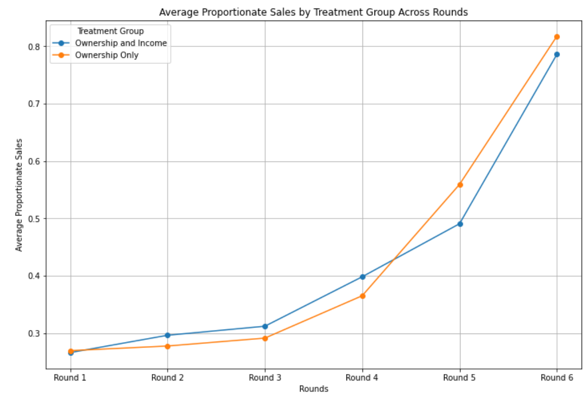

Figure 6: Average proportionate sales.

In Figure 5, the average sales for both groups gradually decrease as the rounds progress. This suggests that as time passes, fewer animals are available to sell in both groups. Although both groups are selling less over time, the sales of participants belonging to the ownership and income group are slightly ahead in absolute terms. However, Figure 6 reveals a more nuanced picture showing the selling behavior of each group to the herd size in each round. Here, both groups start similarly, but as the rounds go by, the ownership only group begins to sell more, particularly in the later rounds. By the time we reach Round 6, this group outperforms Ownership and Income in terms of sales efficiency despite the overall drop in sales seen in the first graph.

As mentioned previously, optimally, participants in the Ownership and income group should hold their animals till the last round of the game and sell all animals in the last round. Similarly, participants with ownership only should sell all their animals in the second round of the game. In the game, all participants face recurring costs associated with maintaining the animal. Without having control of the income generated from milk production, participants with only ownership might lack the necessary funds to cover these ongoing costs, which is why they should sell all their animals in the second round.

Based on the above graphs, we observe that participants in both groups perform sub-optimally. This may indicate a lack of strategic timing in sales, potentially contributing to the negative normalized payoffs seen in previous analyses. This sub-optimal behavior underscores possible limitations in participants' familiarity with the decision-making dynamics of animal ownership and sales timing, which may impact their overall performance in the game.

The sub-optimal behaviors may also be explained due to the additional expenses in each round that are unrelated to ECF, particularly in the case of the Ownership only group. Given these financial pressures, participants with ownership alone might be compelled to hold onto their animals longer, hoping for a better opportunity to sell at a higher price or to offset their cumulative costs. This strategy, however, can backfire if the maintenance cost of holding the animals outweighs the other non-ECF-related expenses, leading to diminished returns or even losses by the final rounds. The behavior observed in the ownership-only group suggests a cautious but potentially costly approach. The delay in sales reflects a tension between immediate financial constraints and the hope for future gains.

This behavior aligns with findings from several studies. Zimmerman and Carter (2003) discuss how asset-poor households often face liquidity constraints, forcing them to sell productive assets like livestock during financial stress, perpetuating poverty by reducing future income-generating capacity. Barrett et al. (2001) highlight that households in rural Africa with limited income from livestock products are more likely to sell their animals prematurely due to the financial burden of recurring costs like feed and healthcare. Dercon and Krishnan (1996) show that households with diversified income sources manage these costs better and avoid distress sales. At the same time, those relying solely on asset ownership face liquidity shortages that lead to sub-optimal liquidation of assets. Thus, participants with ownership and income from milk production can manage costs strategically, maintaining their assets longer and optimizing their payoffs and individual well-being.

5.3 Robustness Check: Zero Inflated Negative Binomial

Based on the data for the outcome of the number of calves vaccinated, it was observed that most participants chose to vaccinate their entire herd. Hence, an exploratory analysis was conducted using a Zero Inflated Negative Binomial(ZINB) model to examine the relationship between women's empowerment and vaccination decisions. [11]. A zero-inflated Poisson regression was also considered to model the relationship. However, after conducting a likelihood ratio test for over-dispersion with a p-value of 0.0182, ZINB was chosen.

The outcome variable for vaccine decision in the original OLS regression is a count variable from 0 to 10. For the ZINB model, the outcome was modified to 10 - the number of calves the participants chose to vaccinate. Hence, the outcome of interest in this model is $Cows\_nvacc$, that is, the number of $non-vaccinated$ cows in the herd. The following Figure 7 shows the distribution of the outcome variable.

[11] Note that the analysis using a ZINB model is not pre-specified

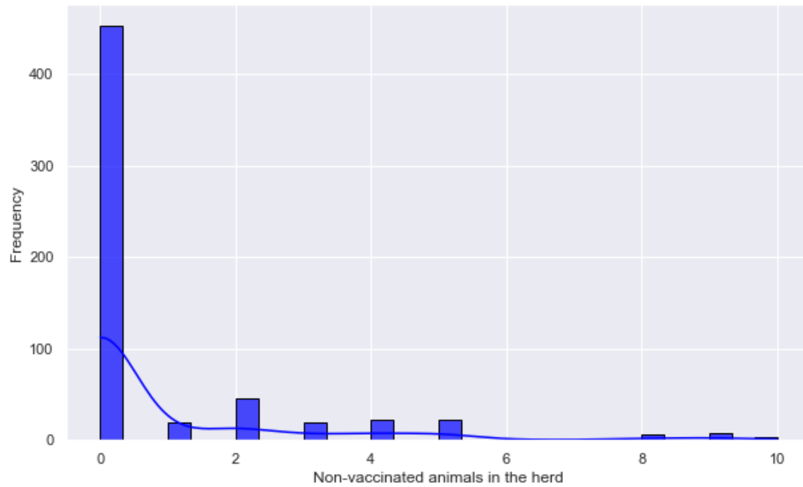

Figure 7: Distribution of the number of non-vaccinated cows in the herd

The data reveals a pronounced spike at zero for the number of non-vaccinated cows in the herd, and significantly lower frequencies for other counts (See Figure 7). This substantial excess of zeros, coupled with the sparse distribution of non-zero counts, indicates that the data are zero-inflated. The ZINB model is designed to handle such data characteristics. Given the clear indication of zero inflation in the dataset, the ZINB model provides a more suitable and precise fit. The ZINB model incorporates a two-part process: one part accounts for the generation of excess zeros, while the other part models the count data using a Negative Binomial distribution. This approach allows the model to reflect the underlying data structure more accurately by addressing the overabundance of zeros and the dispersion of non-zero counts.

Table 7 shows the results of the ZINB model [12]. The results from the logistic regression component are consistent with the OLS model. Specifically, control over ownership and income and control over ownership only significantly increases the probability of zero unvaccinated cows (i.e., vaccinating all cows) in Game 2. Ownership alone, though less pronounced than the combined effect of ownership and income in both games.

The Negative Binomial regression component of the ZINB model analyzes the count of unvaccinated cows, given at least one vaccination. The results show neither control of ownership and income nor control of ownership alone significantly impact the count of unvaccinated cows once non-zero counts are considered. Thus, according to the ZINB model, empowerment does have an impact on the adoption of vaccines. Still, it does not provide any information on how many additional cows are

[12] See Appendix Table 13 for pooled results.

vaccinated due to empowerment compared to the income-only group. This finding may also suggest that socioeconomic factors play a crucial role in preventing non-vaccination but do not significantly influence the extent of undervaccination when it occurs. For instance, access to veterinary services is vital for effective vaccination. Farmers may struggle to get vaccines or veterinary assistance in regions with limited veterinary infrastructure, such as remote areas of East Africa. This is supported by (Di Giulio et al., 2009), which shows that proximity to veterinary services greatly influences vaccination coverage.

	(Game 1) Vaccine decision	(Game 2) Vaccine decision
Logistic Regression model: Probability of observing zero unvaccinated cows		
Inflate Intercept	-0.216	-0.190
	(0.957)	(0.843)
Inflate Ownership and income	0.196	0.919***
	(0.289)	(0.279)
Inflate Ownership only	-0.395	0.971***
	(0.274)	(0.273)
Negative Binomial model conditional on at least one vaccination		
Intercept	1.459***	2.171***
	(0.323)	(0.259)
Ownership and income	0.157	0 -0.027
	(0.134)	(0.149)
Ownership only	0.137	-0.114
	(0.118)	(0.144)
Controls	Yes	Yes
Stratum FE	Yes	Yes
Income only Mean	9.363	8.753
Observations	602	602

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Whereas the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are indicator variables determining whether subjects are assigned in that particular group. Stratum FE are fixed effects refer to the strata the participant belongs to in the experiment. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant. *p<0.1; **p<0.05; ***p<0.01

Table 7: Zero Inflated Negative Binomial

5.4 Heterogeneous treatment effects: Cattle owned at baseline and ownership rights over them.

There is potential to believe that subjects who own more cattle or have greater ownership rights over their animals may behave differently in the game. For instance, Cameron and Shah (2015) found that individuals who experienced more natural disasters were more risk-averse in experimental settings, indicating that past experiences with real-world variables influenced their game behavior. Additionally, Barr and Genicot (2008) showed that participants' social networks affected their trust levels and cooperative behavior in trust games, suggesting that pre-existing social ties and economic variables can significantly bias experimental outcomes. These examples illustrate how participants' real-world conditions and baseline variables can shape their decisions and behaviors in experimental games, potentially leading to systematic biases in the results.

Hence, a secondary analysis was conducted to examine the heterogeneous treatment effects based on the animals owned solely by the participants and the ownership rights they could exercise over them. An ownership rights score was constructed based on the one defined in WELI. Participants were asked whether they could exercise the following rights on the cattle they owned in real life: give as a gift, sell, loan to someone else, pledge as collateral or slaughter. A dummy variable was coded for each of the ownership rights and an ownership rights score by summing the same. Table 8 shows the results from the heterogeneous treatment effects on outcomes due to number of cattle owned, represented by Real cows owned, at baseline and ownership rights over the same, represented by the Real rights index [13].

As observed in the above Table 8, the overall results for the interaction terms in the analysis are not statistically significant, indicating a lack of heterogeneity in treatment effects based on the baseline factors considered. The absence of significant interaction effects suggests that the baseline characteristics of participants do not influence their decisions within the game. Additionally, the lack of significant interaction effects also supports the notion that the experiment is well-randomized. In a well-randomized experiment, any pre-existing differences between participants should be evenly distributed across treatment groups, ensuring that the observed outcomes are primarily due to the experimental conditions rather than external baseline factors. As a result, we can infer that the decisions players make in the game are driven by the experimental conditions themselves rather than by any pre-existing disparities among the participants.

[13] See Appendix Table 14 for pooled results.

	(Game 1) Vaccine decision	(Game 2) Vaccine decision	(Game 1) Payoffs	(Game 2) Payoffs
Ownership and income	0.052	0.515	224.7***	276.5***
	(0.358)	(0.427)	(70.849)	(89.625)
Ownership only	-0.809**	0.443	-512.3***	-292.5***
	(0.362)	(0.391)	(72.443)	(85.784)
Real rights index	-0.432*	-0.338	-55.3	-57.9
	(0.228)	(0.280)	(45.449)	(61.437)
Real cows owned	-0.010	0.008	2.8**	2.4
	(0.015)	(0.027)	(1.186)	(5.795)
Ownership and income × Real rights	0.071	0.188	67.3	87.3
	(0.265)	(0.344)	(53.183)	(72.335)
Ownership and income × Real cows owned	-0.048	-0.035	-6.6	-9.9
	(0.038)	(0.045)	(5.954)	(8.910)
Ownership only × Real rights	0.491*	0.299	47.2	52.1
	(0.278)	(0.322)	(54.680)	(70.281)
Ownership only × Real cows owned	-0.052	-0.023	-0.5	-7.2
	(0.033)	(0.033)	(3.057)	(6.223)
Controls	Yes	Yes	Yes	Yes
Stratum FE	Yes	Yes	Yes	Yes
Income only Mean	9.323	8.668	1849.7	1718.9
Observations	602	602	602	602

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Where as the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are indicator variables determining whether subjects are assigned to that particular group. Real cows owned are the number of cows owned by the participant solely. Real rights index is a variable constructed by summing the rights participants could exercise over the animals they own solely: this includes give as a gift, sell, loan to someone else, pledge as collateral or slaughter. Stratum FE are fixed effects refer to the strata the participant belongs to in the experiment.The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant.
*p<0.1; **p<0.05; ***p<0.01

Table 8: HTE: Cattle owned at baseline and ownership rights over them.

5.5 Heterogeneous treatment effects: Risk of infection.

In this section, I examine the heterogeneous treatment effects of risk of infection in the game on the outcomes. Table 9 below shows the results for the mentioned specification [14]. The risk of infection is the probability of a non-vaccinated animal falling sick due to ECF. The risk of infection was drawn from a uniform distribution [0,10] and was balanced across treatments (See Appendix Table 17 and Table 18).

[14]See Appendix Table 15 for pooled results.

	(Game 1) Vaccine decision	(Game 2) Vaccine decision	(Game 1) Payoffs	(Game 2) Payoffs
Ownership and income	-0.040	0.198	281.9***	333.6***
	(0.364)	(0.358)	(79.117)	(68.167)
Ownership only	0.043	0.469	-439.7***	-294.3***
	(0.330)	(0.336)	(71.966)	(69.411)
Risk of ECF	-0.080	-0.596*	-46.7	-141.9***
	(0.387)	(0.355)	(88.554)	(54.525)
Ownership and income × Risk	0.105	0.888	19.9	51.3
	(0.633)	(0.583)	(135.262)	(118.295)
Ownership only × Risk	-0.726	0.530	-27.0	87.7
	(0.609)	(0.515)	(124.140)	(97.658)
Controls	Yes	Yes	Yes	Yes
Stratum FE	Yes	Yes	Yes	Yes
Income only Mean	9.323	8.668	1849.7	1718.9
Observations	602	602	602	602

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Where as the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are indicator variables determining whether subjects are assigned in that particular group. Risk of infection is a game-level variable referring to the probability of an unvaccinated animal getting infected due to ECF. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant. *p<0.1; **p<0.05; ***p<0.01

Table 9: HTE: Risk of infection in the game.

As seen in Table 9, in the case of Risk of ECF, the results in Game One and Game Two are negative for the outcome of the vaccine decision. However, the result is only statistically significant at a 10% level in Game Two. Thus, as the risk of infection increases, participants may choose to vaccinate less, which is counter-intuitive. In the case of interaction terms, the results between treatment arms and risk of infection are also insignificant, indicating that baseline factors such as ownership, income, and risk perception do not significantly affect vaccine decisions or payoffs. While this finding suggests that the experiment was well-randomized, it also presents a potential caveat.

I also examined the heterogeneous treatment effect of risk of infection by bins on outcome variables [15]. Three risk bins were created, namely low, medium, and high. If the risk of infection was between 0 and 0.3, it was termed low, whereas the one between 0.3 and 0.6 was called medium. Similarly, the risk of infection above 0.6 was labeled as high risk. Table 10 shows the results of

[15] Note this analysis was not pre-specified.

heterogeneous treatment effects of risk of infection by bins on the outcomes [16].

Holding all other variables constant, high risk reduces the vaccination by 0.207 cows relative to low risk in Game One. However, this result is not statistically significant. A similar result in magnitude is observed in the case of medium risk with a coefficient of -0.400, which is weakly significant at a 10% level. In Game Two holding other variables constant, high risk increases the vaccination rate by 0.236 cows, and medium risk increases the vaccination rate by 0.233 cows compared to low risk. Although this result is not statistically significant, intuitively, it makes sense. As the risk of ECF in the game increases, in an attempt to protect animals, participants choose to vaccinate more.

	(Game 1) Vaccine decision	(Game 2) Vaccine decision	(Game 1) Payoffs	(Game 2) Payoffs
Ownership and income	0.036	0.660***	293.4***	364.1***
	(0.176)	(0.217)	(36.226)	(47.606)
Ownership only	-0.321*	0.760***	-453.6***	-245.4***
	(0.188)	(0.204)	(35.734)	(46.974)
High risk	-0.207	0.236	-33.5	-15.3
	(0.177)	(0.190)	(33.484)	(43.350)
Medium risk	-0.400*	0.233	-35.9	10.5
	(0.219)	(0.190)	(40.080)	(39.224)
Controls	Yes	Yes	Yes	Yes
Stratum FE	Yes	Yes	Yes	Yes
Income only Mean	9.323	8.668	1849.7	1718.9
Observations	602	602	602	602

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Where as the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are indicator variables determining whether subjects are assigned to that particular group. Risk of infection is a game-level variable referring to the probability of an unvaccinated animal getting infected due to ECF. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant. *p<0.1; **p<0.05; ***p<0.01

Table 10: HTE: Risk of infection by bin in the game.

Thus, the results for Game Two in 10 indicate a positive relationship between the risk of infection and vaccination, but the results from Table 9 present a potential caveat. The lack of significant results for these interactions in Table 9 may imply that other underlying factors, not accounted

[16] See Appendix Table 16 for pooled results.

for in the current analysis, are more influential in driving participants' decisions and outcomes. Unmeasured variables might play crucial roles. This potential oversight highlights the importance of considering a broader range of factors in future research. For instance, incorporating variables that capture individual motivations and contextual conditions could provide a more comprehensive understanding of the decision-making processes involved. Qualitative research methods, such as interviews or focus groups, could offer deeper insights into participants' motivations and the factors influencing their decisions. Lastly, prior disease and vaccine knowledge and usage could also be essential factors that influence decisions (See Appendix Table 19 for more information).

6 Discussion and Conclusion

This study investigates the causal impact of women's empowerment on individual well-being in the context of ECF management among women in Kenya, using a lab-in-the-field experiment approach. By defining empowerment based on WELI, this research provides an understanding of how decision-making autonomy and control over livestock assets and income influence animal health and individual economic outcomes. The findings highlight the significant benefits of comprehensive empowerment, where women with control over both ownership and income are more likely to vaccinate their cattle and achieve higher economic payoffs compared to those with partial control.

Empowerment is defined through two key dimensions: decision-making related to asset ownership and control over the income generated from livestock milk production. The experiment's design ensures a rigorous assessment of empowerment levels by randomly assigning participants to various groups, which is indicative of different levels of control. This method helps isolate the effects of empowerment from other confounding factors. The results consistently show that women with full control over both ownership and income (Full rights) not only vaccinate more but also achieve higher economic payoffs, highlighting the importance of holistic empowerment. This finding aligns with existing literature that emphasizes the critical role of comprehensive resource control in enhancing decision-making and economic outcomes (Duflo, 2003a; Peterman et al., 2014).

The study also explores the effects of partial empowerment, revealing that women with control over ownership alone (Partial ownership rights) vaccinate more than those with control over income flow only (Partial income rights). However, the economic payoffs for those with ownership alone are significantly lower, indicating that ownership without income control can limit economic well-being. This finding underscores the necessity for policies that ensure both asset control and income support to optimize health and economic benefits. The insights gained from this research can inform future interventions and policy frameworks aimed at empowering women in the livestock sector, ultimately contributing to improved household well-being and sustainable livestock management (Allendorf, 2007; Doss, 2013).

The analysis of Normalized Payoffs reveals that participants in both Ownership and income and Ownership only groups earned significantly lower payoffs relative to potential maximums, indicating sub-optimal decision-making. This shortfall suggests that ownership without prior management experience may hinder effective payoff maximization. The sales trend analysis further shows that while both groups reduce sales as rounds progress, the Ownership only group eventually achieves higher sales efficiency, adjusting more strategically in later rounds. Ideally, Ownership and income participants would retain animals until the final round, while Ownership only participants should sell by round two to offset maintenance costs. The deviations observed highlight potential gaps in strategic familiarity, indicating that asset control coupled with skill development could enhance decision-making and economic outcomes for participants.

The study also identifies several important heterogeneous effects that merit further exploration. The lack of significant results for interaction terms suggests that baseline factors such as sole cattle ownership, ownership rights, existing disease awareness, and vaccine control usage do not significantly affect vaccine decisions or payoffs, indicating that the experimental design was well-randomized. However, in the case of risk of infection, the insignificant results also imply potential limitations, as other underlying factors not accounted for in the current analysis might play crucial roles in decision-making processes. Future research should consider incorporating a broader range of variables to provide a more comprehensive understanding of the factors driving these decisions. For instance, qualitative methods, such as interviews or focus groups, could also offer deeper insights into participants' motivations and contextual influences, enhancing the overall validity and applicability of the findings (Kilic and Moylan, 2016; Doss et al., 2020).

In summary, this study provides robust evidence that empowering women with comprehensive control over livestock assets and income can significantly enhance their decision-making capacity and economic outcomes in the context of ECF management. By highlighting the critical importance of holistic empowerment, these findings contribute to the broader discourse on gender equality and sustainable development in the livestock sector. They particularly focus on the need for implementing integrated approaches that combine asset ownership and income control to maximize health and economic benefits for women and their households (Thomas, 1990b; Beegle et al., 2001b; Deininger et al., 2013b).

Policies that grant women full rights to ownership and income can greatly enhance their ability to make effective decisions regarding livestock management, particularly in the adoption of technology. To achieve this, government and development agencies might consider revising or enacting legislation that supports joint ownership and income rights for married couples or co-owners in agricultural settings. Additionally, financial support programs could be established to help women acquire and maintain livestock, ensuring they have both the authority and economic means to manage their assets effectively. The study's findings on selling behaviors related to different levels of asset control emphasize the impact of liquidity constraints when income from milk production is absent. To address these constraints, policies should provide access to credit or financial services for individuals with ownership rights. This comprehensive approach could empower women and contribute to broader economic development by adopting technology.

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A Parameters calibrated based on baseline data

The following table shows the parameters that were calibrated for the game using the AHIL baseline data.

Parameters	Data	Points in game
Maintenance cost M_t	900 (drops by a third for vaccinated animals 900/3 = 300)	9 (3)
Treatment cost : S	2000	20
Vaccination fixed cost: F	1000	10
Milk output/liter/day	3*90 = 120	1.2
Reduction in milk output if infected	1*90 = 90	0.9
Milk Price/liter	40	0.4
Milk revenue generated every 3 months per cow	120*40 = 4800 (for healthy cow) ; 90*40 = 3600 (for an infected cow)	48; 36

Table 11: Parameters calibrated based on baseline data

B Pooled results

B.1 OLS Model

	Vaccine Decision	Payoffs
Ownership and income	0.273**	323.6***
	(0.137)	(28.460)
Ownership only	0.207	-352.2***
	(0.137)	(27.121)
Controls	Yes	Yes
Stratum FE	Yes	Yes
Income only Mean	8.973	1779.8
Observations	1,204	1,204

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Whereas the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are an indicator variables determining whether subjects are assigned in that particular group. Stratum FE are fixed effects refer to the strata the participant belongs to in the experiment. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant.
*p<0.1; **p<0.05; ***p<0.01

Table 12: OLS Pooled Results

B.2 ZINB Model

	(Pooled) Vaccine decision
Logistic Regression model: Probability of observing unvaccinated cows	
Inflate Intercept	-0.452
	(0.792)
Inflate Ownership and income	0.531**
	(0.170)
Inflate Ownership only	0.279
	(0.182)
Negative Binomial model conditional on at least one vaccination	
Intercept	1.955***
	(0.238)
Ownership and income	0.042
	(0.100)
Ownership only	-0.027
	(0.086)
Controls	Yes
Stratum FE	Yes
Income only Mean	9.081
Observations	1204

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Whereas the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are indicator variables determining whether subjects are assigned in that particular group. Stratum FE are fixed effects refer to the strata the participant belongs to in the experiment. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant. *p<0.1; **p<0.05; ***p<0.01

Table 13: Pooled Zero Inflated Negative Binomial

B.3 HTE: Cattle owned at baseline and ownership rights over them

	(Pooled) Vaccine decision	(Pooled) Payoffs
Ownership and income	0.197	245.6***
	(0.277)	(55.891)
Ownership only	-0.152	-405.2***
	(0.289)	(53.406)
Real rights index	-0.313*	-57.6
	(0.181)	(39.264)
Real cows owned	0.009	2.3
	(0.012)	(2.516)
Ownership and income × Real rights	0.154	80.2*
	(0.209)	(42.521)
Ownership and income × Real cows owned	-0.037	-8.9*
	(0.028)	(5.108)
Ownership only × Real rights	0.338	51.8
	(0.229)	(43.774)
Ownership only × Real cows owned	-0.016	-2.9*
	(0.014)	(1.755)
Controls	Yes	Yes
Stratum FE	Yes	Yes
Income only Mean	8.973	1779.8
Observations	1,204	1,204

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Where as the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are indicator variables determining whether subjects are assigned to that particular group. Real cows owned are the number of cows owned by the participant solely. Real rights index is a variable constructed by summing the rights participants could exercise over the animals they own solely: this includes give as a gift, sell, loan to someone else, pledge as collateral or slaughter. Stratum FE are fixed effects refer to the strata the participant belongs to in the experiment. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant. *p<0.1; **p<0.05; ***p<0.01

Table 14: HTE Pooled: Cattle owned at baseline and ownership rights over them.

B.4 HTE: Risk of infection

	(Pooled) Vaccine decision	(Pooled) Payoffs
Ownership and income	-0.065	292.4***
	(0.296)	(57.850)
Ownership only	0.190	-371.3***
	(0.247)	(47.672)
Risk of ECF	-0.491	-118.9***
	(0.309)	(44.997)
Ownership and income × Risk	0.689	63.5
	(0.517)	(96.745)
Ownership only × Risk	0.047	41.2
	(0.436)	(74.215)
Controls	Yes	Yes
Stratum FE	Yes	Yes
Income only Mean	8.973	1779.8
Observations	1,204	1,204

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Where as the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are indicator variables determining whether subjects are assigned in that particular group. Risk of infection is a game level variable referring to the probability of an unvaccinated animal getting infected due to ECF. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant. *p<0.1; **p<0.05; ***p<0.01

Table 15: HTE Pooled: Risk of infection in the game.

B.4.1 HTE: Risk of infection by bin in the game

	(Pooled) Vaccine decision	(Pooled) Payoffs
Ownership and income	0.284**	326.4***
	(0.133)	(28.121)
Ownership only	0.220	-349.4***
	(0.136)	(27.142)
High risk	-0.008	-31.7
	(0.126)	(25.715)
Medium risk	-0.071	-4.0
	(0.133)	(25.548)
Controls	Yes	Yes
Stratum FE	Yes	Yes
Income only Mean	8.973	1779.8
Observations	1,204	1,204

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Whereas the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are indicator variables determining whether subjects are assigned in that particular group. Risk of infection is a game-level variable referring to the probability of an unvaccinated animal getting infected due to ECF. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant. *p<0.1; **p<0.05; ***p<0.01

Table 16: HTE pooled: Risk of infection by bin in the game.

C Distribution of risk of infection across treatments.

The following Tables 17 and 18 show the summary statistics of distribution of risk of infection in Games one and two respectively. I conducted an ANOVA one-way F-test to examine whether the risk of infection was balanced across treatments and to verify if randomization worked. In Game 1, the ANOVA test results (F = 0.898, p = 0.408) indicate no statistically significant differences in the mean probabilities across the three treatment groups: “Ownership and income”, “Income only” and “Ownership only” This suggests that the probabilities assigned across these groups were well-balanced, supporting the validity of the randomization.

Game one	Count	Mean	Std	min	25%	50%	75%	max
Ownership and income	255.0	0.49	0.28	0.0	0.3	0.4	0.9	1.0
Income only	189.0	0.46	0.29	0.0	0.2	0.4	0.8	1.0
Ownership only	188.0	0.50	0.28	0.0	0.3	0.4	0.8	1.0

Table 17: Summary statistics of risk of infection across treatments in Game one.

Similarly, in Game 2, ANOVA results (F = 0.456, p = 0.634) again show no statistically significant differences in the probability means across treatments. This consistency across both games reinforces that randomization was effective, ruling out imbalances in probabilities as a potential factor influencing the outcomes. Given these balanced distributions, the counter-intuitive results observed in risk-related findings are likely not attributable to issues with randomization.

Game two	Count	Mean	Std	min	25%	50%	75%	max
Ownership and income	186.0	0.48	0.28	0.0	0.2	0.5	0.7	1.0
Income only	217.0	0.51	0.29	0.0	0.3	0.5	0.7	1.0
Ownership only	199.0	0.53	0.67	0.0	0.2	0.5	0.7	1.0

Table 18: Summary statistics of risk of infection across treatments in Game two.

D Heterogeneous treatment effects: Prior disease and vaccine knowledge and usage.

Prior disease and vaccine knowledge significantly influences farmers' willingness and ability to vaccinate their animals, as demonstrated by various studies (Jumba et al., 2020b; Allan and Peters, 2021; Enticott et al., 2020). Therefore, to examine the impact of awareness about the disease and management responses, this section presents the heterogeneous treatment effects on outcomes. It is important to note that this is an exploratory analysis and was not pre-specified. An exit survey was conducted following the experiment to examine this effect specifically. Participants were asked if they were aware of ECF before the discussion that day, whether they had any ECF cases in their herd over the past four months, if they knew about the vaccine available for ECF prevention before the discussion, and whether they had vaccinated their cattle against ECF in the past year. Table 19 shows the results for heterogeneous treatment effects based on prior disease and vaccine knowledge and usage.

The analysis reveals that awareness of ECF on average, holding other variables constant, tends to reduce both the vaccination decisions and payoffs. This could indicate that participants who are aware of ECF may already have some level of caution or alternative measures in place, leading them to vaccinate less frequently and possibly face lower payoffs due to the costs associated with these measures. The results for the interaction terms between vaccine awareness and treatment groups are also statistically significant. Surprisingly participants who only have ownership rights and are aware of the ECF earn higher payoffs which is opposite compared to the result in previous section (payoffs are negative).

Lastly, in the case of interaction terms of ECF cases, vaccine awareness, and vaccination behavior, the overall results are statistically insignificant. The lack of significant interaction terms in our analysis suggests that the baseline awareness of ECF and vaccine measures do not significantly alter the effects on vaccine decisions and payoffs in the game. As a result, the findings are more robust, suggesting that the observed effects are consistent across different subgroups of participants. This uniformity implies that the experimental interventions had a consistent impact regardless of variations in baseline characteristics, thereby enhancing the generalizability of the results. It also underscores the efficacy of the randomization process in evenly distributing these characteristics across treatment groups, ensuring that the results are not confounded by pre-existing differences among participants due to disease and vaccine knowledge and usage.

	(Game 1) Vaccine decision	(Game 2) Vaccine decision	(Pooled) Vaccine decision	(Game 1) Payoffs	(Game 2) Payoffs	(Pooled) Payoffs
ECF Aware	-0.486**	-1.089***	-0.825***	-115.8**	-234.1***	-177.1***
	(0.214)	(0.282)	(0.176)	(47.815)	(57.812)	(37.154)
ECF Case	-0.318	-0.628	-0.487*	-55.9	-147.4	-101.7*
	(0.305)	(0.409)	(0.274)	(68.773)	(91.508)	(60.191)
ECF Vacc	0.136	0.115	0.058	29.6	-25.9	3.6
	(0.543)	(0.588)	(0.469)	(116.314)	(127.332)	(96.640)
ECF Vacc Aware	-0.207	-0.646	-0.448*	-37.3	-128.8	-91.5*
	(0.273)	(0.402)	(0.262)	(56.063)	(85.170)	(54.750)
Full rights	-0.392	-0.641	-0.575**	62.2	-126.6	-25.1
	(0.317)	(0.439)	(0.240)	(66.049)	(103.932)	(55.252)
Full rights × ECF Aware	0.648*	1.027**	0.900***	295.3***	452.7***	369.3***
	(0.389)	(0.491)	(0.288)	(79.854)	(114.908)	(63.582)
Full rights × ECF Case	-0.032	0.945*	0.385	-57.1	162.8	42.3
	(0.485)	(0.513)	(0.358)	(96.168)	(106.103)	(71.558)
Full rights × ECF Vacc	-1.147	-0.198	-0.582	-233.6	-120.9	-161.1
	(1.501)	(0.719)	(0.804)	(272.151)	(181.078)	(156.367)
Full rights × Vacc Aware	-0.147	0.479	0.141	31.2	221.3**	125.2**
	(0.388)	(0.482)	(0.306)	(78.450)	(103.846)	(63.055)
Ownership only	-0.494	-0.469	-0.519**	-501.4***	-532.7***	-516.8***
	(0.337)	(0.325)	(0.249)	(71.159)	(49.199)	(39.255)
Ownership only × ECF Aware	0.384	1.258***	0.856***	57.0	231.2***	145.3***
	(0.416)	(0.395)	(0.305)	(85.670)	(72.037)	(51.496)
Ownership only × ECF Case	-0.356	0.299	-0.033	4.6	153.6	69.5
	(0.483)	(0.477)	(0.359)	(91.831)	(110.933)	(70.913)
Ownership only × ECF Vacc	-0.732	-0.063	-0.295	-45.8	-8.5	-47.4
	(0.861)	(0.688)	(0.654)	(154.921)	(136.788)	(118.065)
Ownership only × Vacc Aware	0.274	0.130	0.214	45.3	144.2	107.8*
	(0.465)	(0.467)	(0.320)	(83.273)	(98.717)	(63.208)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Stratum FE	Yes	Yes	Yes	Yes	Yes	Yes
Income only Mean	9.323	8.668	8.973	1849.7	1718.9	1779.8
Observations	602	602	1,204	602	602	1,204

Note: Standard errors clustered at the individual level are reported in parentheses. The dependent variable vaccine decision indicates the number of cows chosen to vaccinate. Where as the dependent variable payoffs are points earned by participants at the end of each game. Ownership and income and Ownership only are an indicator variables determining whether subjects are assigned in that particular group. ECF Aware is a dummy variable indicating whether a participant was aware of ECF prior to the experiment. ECF case refers to the number of cases detected in the herd in the last 4 months. ECF Vacc Aware is a dummy variable indicating participant's awareness about the vaccine. ECF Vacc is a dummy variable indicating whether the participant has ever vaccinated their cattle against ECF. The control variables include: Probability of underlying risk of infection in the game, Maintenance cost faced in the game (high or low), Education level of the participant, Age of the participant. *p<0.1; **p<0.05; ***p<0.01

Table 19: HTE: Prior disease and vaccine knowledge and usage.