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*Original Research Article*

# An evaluation of economic returns from east coast fever control through infection and treatment method at household level in Nandi and Uasin-Gishu Counties of Kenya

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**Kenya has a vibrant small-scale based dairy industry that plays an important economic and nutrition role in the lives of many people, ranging from farmers to petty milk traders ("hawkers"), processors, and consumers. However, the high incidence of tick-borne livestock diseases in Kenya is a major challenge to the dairy industry in the country. East Coast Fever (ECF) is one of these diseases, and the ECF Infection and Treatment Method (ECFIM) is one of the novel strategies that are being promoted to control ECF in Kenya. This study evaluated the economic returns from the adoption of ECFIM vaccine by small-scale dairy producers in a high potential dairy producing area of the Rift Valley region of Kenya. A cross sectional study of a sample of 330 randomly selected households from two counties in that region shows that the ECF-vaccinating households realized an overall net economic return of Kshs 44,575 (about US$ 450) per cow per year while the ECF non-vaccinating households realized a net loss of Kshs 9,975 (about US$ 100) per cow per year. The Odds Ratio estimate in this study actually shows that ECF non-vaccinated dairy animals are twice more likely to die from the ECF disease than the vaccinated dairy animals.**

**Key words:** Tick-borne livestock diseases, East Coast fever, control methods, infection and treatment method, economic returns.

## INTRODUCTION

Kenya has a vibrant small-scale based dairy industry that plays an important economic and nutrition role in the lives of many people, ranging from farmers to petty milk traders ("hawkers"), processors, and consumers. Thorpe et al. (2000) attribute the success of dairy production by smallholders in Kenya to the presence of a significant dairy cattle population that was estimated at about 6.7 million by the early 2000s (SDP, 2006). However, the high incidence of tick-borne livestock diseases in Kenya is a major challenge to the dairy industry in the country.

Tick-borne diseases are most prevalent in the tropical and subtropical regions of the developing world where they exert significant and negative impacts on the productivity of and hence economic returns to livestock production (Salih et al., 2015). Castro et al. (1997) estimated that the annual global costs associated with ticks and tick-transmitted pathogens in cattle amount to between US$ 13.9 billion and US$ 18.7 billion. Among the tick-borne diseases, Babesiosis, Bovine Anaplasmosis and East Coast Fever (ECF) constitute the most economically important animal disease problems in Africa (Young et al., 1988).

ECF is an acute disease of cattle and is characterized by high fever, swelling of the lymph nodes, dyspnea, and high mortality. The etiological agent of ECF, *Theileria parva*, is a protozoon that is transmitted to cattle through the bites of the tick *Rhipicephalus appendiculats* (The Mercks Veterinary Manual, 3rd edition 1997). The proceedings of a workshop on the Epidemiology of Ticks and Tick-borne

Diseases in East, Central and Southern Africa in 1996 indicate that ECF is by far the most economically important tick-borne disease in Kenya Irvin et al. (1996). The disease (ECF) prevents the introduction of the more productive and ECF susceptible exotic dairy breeds of cattle to ECF endemic regions. Therefore, ECF directly and considerably hampers the development of the livestock sub-sector in ECF endemic regions.

**Statement of the Problem**

East Coast Fever (ECF) poses the most significant threat to the cattle sub-sector of the livestock sector in Kenya due to its high morbidity and mortality which result in significant production losses in all cattle production systems. Berkvens et al. (1989) estimated that mortality rates under endemically stable conditions occur mostly in calves and that they may vary from zero (0) to fifty (50) percent. Where endemic instability exists, mortality may be as high as 100 percent.

From an economic perspective, direct production losses due to ECF can be attributed to morbidity and mortality, while indirect production losses occur when the ECF disease acts as a constraint to the use of improved cattle (Mukhebi et al., 1989). Animals which recover from ECF may suffer from weight loss, produce low milk output, provide less draft power and possibly suffer from reduced fertility and delays in reaching maturity. In addition, recovered animals also remain carriers and can spread infection (Brown 1985). Given the economic importance of ECF, it would be informative to assess the costs and benefits of alternative ECF control strategies.

Nyangito et al (1996) through simulation analysis found that ECF immunization as a strategy in ECF control was superior to the conventional tick-borne diseases control through acaricides application and dipping. The most preferred ECF control strategy was to adopt vaccination and combine it with a 75% reduction in acaricides use. Even though Nyangito et al. (1996) found that ECF immunization was financially and economically viable for small scale farms in Kenya, theirs was a simulation study, and a more detailed case study at farm level would have been needed to validate that result.

Mukhebi et al. (1989) appears to be the only study that came close to making an estimate of the costs of ECF control through immunization (the infection and treatment method) in Kenya that the authors of the current article have been able to find. However, the study by Mukhebi et al. (1989) was undertaken at a time when sensitization and awareness among both the policy makers and the livestock keepers on the control of ECF through the infection and treatment method (ECFIM) were at their initial stages and while field trials were still ongoing. Consequently, the livestock keepers had not adopted ECFIM by then. Therefore, any serious evaluation of economic returns from ECFIM at the time of the Mukhebi, et al. (1989) study would have been largely ex-ante or simulative in nature.

The current study evaluated the economic returns from the adoption of ECFIM vaccine as a strategy in the control of ECF by small scale dairy producers in a high potential dairy producing area of the Rift Valley region of Kenya through a cross sectional study of a randomly selected sample of 330 dairy producing households in that region. The current study is thus ex-post in nature.

Over the last decade or so, the Directorate of Veterinary Services (DVS) in Kenya has undertaken a lot of extension-related sensitization of the livestock keepers on the benefits of adopting ECFIM as opposed to the use of the conventional ticks and ECF control through dipping in acaricides. During the same time, the DVS has also enlisted many ECF vaccine distributors to facilitate adoption of ECFIM in the major dairy producing project areas under a liberalized policy and economic environment in Kenya. The current study thus evaluates and quantifies the costs and benefits of ECFIM under field conditions in small scale dairy farming in the country.

## MATERIALS AND METHODS

### Study area

This study was undertaken in Uasin Gishu and Nandi counties of Kenya. The two counties show some variability in agricultural production systems, with Nandi being a tea growing area with dairy farming and Uasin Gishu being a maize growing area that also practices dairy farming.

Uasin Gishu County covers an area of 3,327 sq km of which 2,995 sq km is arable land; the rest is non-arable land. The County has a human population of 894,179 people, thus reflecting an average population density of about 269 people per square kilometer (NPC, 2010). There are about 375,290 dairy animals in the Uasin-Gishu County of which 81,838 are grade dairy animals (MOLD, 2014). The areas covered in the study in the Uasin-Gishu County included Kaptagat, Strawback and Plateau administrative locations.

The Nandi County covers an area of 2,884 square kilometers and has a human population of 813,803 people, with the average population density being about 286 people per square kilometer. The total livestock population in the Nandi County is 309,038 animals, of which 62,459 are cattle. The areas covered in the study in the Nandi County included Tinderet, Tanykina, Kapsabet, Lessos and Lelchego administrative locations.

### Unit of analysis, sampling and sample size

The population of interest in the study were dairy cattle keeping households, including both those that had adopted the ECF Infection and Treatment Method (ECFIM) and those that had not done so. Hence the sampling unit was a household.

A total of 1,362 households in the 2 study counties had vaccinated against ECF. Through a multistage and stratified random sampling procedure, a sample of 330 households was selected for the study in the two counties. Sample size was determined based on the Dohoo et al. (2003) formula. Through the sampling procedure adopted, it was ensured that the administrative villages (locations) with the highest number of vaccinating households in each administrative sub-county and division were purposively selected for the study. For each county, the households in the selected villages were randomly selected and grouped into vaccinating and non-vaccinating households. The heads of the selected households were then interviewed using both structured and semi-structured questionnaires that had earlier been pretested and adjusted prior to the undertaking of the detailed field investigations. For the purposes of focus group discussions and key informant surveys, the participants were purposively selected.

The interviews were conducted using the commonly understood Swahili language and, if necessary, the local Nandi language using bilingual interpreters. The survey also took time to collect information on the descriptions of the clinical presentations of the ECF disease by the local farmers to determine their knowledge and perception of the disease.

## Modeling

### Bivariate analysis

A bivariate analysis of productive losses was done using the 'with' and 'without' adoption approach. The 'with adoption' approach was represented by the vaccinating households, while the 'without adoption' approach was represented by the non-vaccinating households. To assess the economic cost of the ECF disease, the following formula (Bennett, 2003) was applied:

$$C = (L + R) + (T+P)$$

where: C = economic cost of the disease.

L = the cost of disease in terms of the value of the loss in expected output due to ECF.

R = increase in expenditure on non-veterinary resources due to ECF.

T = the cost of inputs used to treat ECF.

P = the cost of disease prevention measures.

In modeling, the key elements used in the application of the Bennett (2003) formula are presented below:

### Partial budgeting

The partial budgeting technique (as modeled in Table 2) may be used to evaluate the net gain from an enterprise when one production technique (Tick and ECF control through dipping in acaricides in this study) is replaced by another production technique (ECF control through the Treatment and Infection Method (ECFIM) in this study). The cost information (TC) generated from the application of the Bennett (2003) formula (as per Table 1 entries) was used to estimate the net gain (NG) from the adoption of the ECFIM vaccine programme using the Partial Budgeting technique as outlined in Table 2.

Table 2 basically illustrates how the partial budgeting technique can be used to estimate the economic returns from the adoption of the ECFIM vaccination programme in the household's farm management practices. The total cost of the ECF disease (TC) as reflected in Table 1 basically becomes the Cost Saved (CS) in Table 2.

As Table 2 shows, the net gain or benefit (NG) from ECFIM vaccine adoption is calculated by analyzing both the positive and the negative aspects of the adoption of the ECFIM programme by the households in the study area.

### Analysis of Variance (ANOVA) Test

The test of statistical association between whether the livestock was or was not vaccinated against ECF versus expenditure (costs) on various items was undertaken through the Analysis of Variance (ANOVA) technique.

### Data Collection

Primary data were collected through a formal sample survey that was conducted on households using both structured and semi structured questionnaires. Formal focus group discussions (FGDs) and key informant interviews (KIIs) were also carried out using a checklist of the issues to be interrogated. The FGDs and KIIs involved county veterinary officers and officers from the tick control unit in the Directorate of Veterinary Services, appointed vaccine distributors, and managers of dairy co-operative societies.

The primary data to be collected from the households and livestock owners included the types of livestock kept, the uses of livestock, the types of livestock diseases encountered and the methods used to control tick and tick borne diseases.

### Data management and statistical analysis

The data collected from the survey were processed and analyzed using appropriate computer packages, including the SPSS statistical software version 11.0. The association between ECF vaccine adoption and the various household-related factors was examined through statistical analysis, focusing on two primary outcomes: (i) adoption and (ii) non- adoption. Chi-square tests were performed to identify these associations and t-statistic tests were used to test for relationships in the case of continuous variables. The usual tests for statistical significance were applied at the 0.01, 0.05 and 0.10 levels of significance.

## RESULTS

### Descriptive analysis

The descriptive statistics generated through this study

**Table 1**. Modeling the key elements used in the Estimation of the Economic Cost of ECF disease (in Kshs per cow per Year)

| Cost Elements | Description of the cost variable | Mean Cost (Kshs) |
|---|---|---|
| | Value of the loss in expected output due to the presence of a disease | L |
| L | i. opportunistic costs in favor of treating the ECF | L1 |
| | ii. inability to market produce | L2 |
| | Increase in expenditures on non-veterinary resources due to a disease | R |
| R | i. hiring of extra labor, | R1 |
| | ii. ECF disease reporting costs | R2 |
| | The costs of inputs used to treat the disease | T |
| T | i. veterinary consultation fee | T1 |
| | ii. drugs | T2 |
| | The cost of disease prevention measures | P |
| | i. vaccination | P1 |
| P | ii. home spraying | P2 |
| | iii. public dipping | P3 |
| C | Total Cost of ECF disease | C |

**Table 2.** Modeling the partial budget analysis for ECF Vaccinating Households: Costs and Revenues in Kshs per Cow per Year

| **GAINS (Kshs per cow per year)** | | **LOSSES (Kshs per cow per year)** | |
|---|---|---|---|
| 1. Extra Revenue (**ER**) in Kshs | 1. Extra Revenue (**ER**) in Kshs=Milk sales (liters) @Market Price in (Kshs) = Kshs **ER** | 2. Extra Costs (**EC**) in Kshs | Cost of ECF vaccine in Kshs = **EC** |
| 3. Costs Saved (**CS**) in Kshs | Vet consultations CS1 | 4. Revenue Foregone (**RF**) in Kshs | **RF** = Zero |
| | Vet drugs CS2 | | |
| | Acaricide CS3 | | |
| | **CS** = (CS1+CS2+CS3) | | |
| **Total Gain = (ER + CS) = TG** | | **Total Loss = (EC + RF) = TL** | |
| **Net Gain = (TG - TL) = NG** | | | |

included frequencies, means and median score estimates. The study found that the households were practicing both the zero grazing and the free-range grazing systems of production. Zero grazing was normally being practiced in the urban and the peri-urban areas where land sizes were small and generally limited to between ¼ of an acre and 1 acre. This range of land sizes compared drastically with the range of land sizes in the rural areas where free-grazing production system was being practised and where land sizes ranged between 3 and 20 acres.

## Economic losses due to ECF disease

Table 3 derives from Table 1 and summarizes a profile of the economic losses due to ECF disease, stratified by vaccinated and not vaccinated.

Table 3 indicates that the total cost of ECF as a disease to a household amounts to Kshs 34,875 per cow per year.

## Bivariate analysis

Table 4 gives the results from a bivariate analysis of the productivity losses by examining the 'with adoption' and 'without adoption' situations. The 'with adoption' approach represented the vaccinating households while the 'without adoption' approach represented the non-vaccinating households.

From the bivariate analysis, only two types of productivity losses were found to be significant at the P-values of 0.005 and 0.001. These were the Mortality and the ECF-treatment Incurred Costs. From the analysis, the predominant productivity losses associated with ECF disease were the cost of treatment (40%), mortality (16%) and decrease in weight gain (14.6%). Further analysis and the calculation of the Odds Ratio ("OR"), it was evident that non-vaccinated animals were twice more likely to die from the ECF disease than the vaccinated animals.

## Partial budgeting results

Table 5 gives the results from partial budgeting for the positive and negative aspects of adopting the ECFIM vaccine programme by the dairy farming households in the study area.

From Table 5, it is evident that the ECFIM vaccinating household had a net gain of 44,575 Kshs per cow per year deriving from the adoption of the ECFIM vaccine because this led to greater milk yield and reduced expenses on ECF

**Table 3.** Economic cost of ECF disease per household in Kshs. per Cow per Year

| Cost Elements | Description of the cost variable | Mean Cost (Kshs) |
|---|---|---|
| L | Value of the loss in expected output due to the presence of a disease | L |
| | i. opportunistic costs in favor of treating the ECF | 1,450 |
| | ii. inability to market produce | 29,000 |
| R | Increase in expenditures on non-veterinary resources due to a disease | R |
| | i. hiring of extra labor, | 500 |
| | ii. ECF disease reporting costs | 100 |
| | The costs of inputs used to treat the disease | T |
| T | i. veterinary consultation fee | 200 |
| | ii. drugs | 2,000 |
| | The cost of disease prevention measures | P |
| | i. vaccination | 1,325 |
| P | ii. home spraying | 200 |
| | iii. public dipping | 100 |
| C | Total Cost of ECF disease | 34,875 |

Number of valid responses (n) = 48
**Source: Authors' work 2013**

**Table 4:** Results of bivariate analysis of the types of productivity losses

| | (N=459) | | Those Not Vaccinated | Those Vaccinated | | 95% C.I. | | |
|---|---|---|---|---|---|---|---|---|
| **Types of productivity Losses** | **N** | **%.** | **(n=162)** | **(n=168)** | **"OR"** | **Lower** | **Upper** | **p-value** |
| Mortality | 76 | 16.60 | 48 | 28 | 2.1 | 1.24 | 3.57 | **0.005** |
| Abortions | 8 | 1.70 | 4 | 4 | 0.77 | 0.17 | 3.51 | 0.74 |
| Decrease in calving rate | 27 | 5.90 | 12 | 15 | 0.82 | 0.37 | 1.8 | 0.614 |
| Increase in calving interval | 24 | 5.20 | 10 | 14 | 0.72 | 0.31 | 1.68 | 0.450 |
| Decrease in weight gain | 67 | 14.60 | 34 | 33 | 1.08 | 0.64 | 1.86 | 0.761 |
| Increase in labor | 50 | 10.90 | 25 | 25 | 1.04 | 0.57 | 1.91 | 0.889 |
| Incurred costs in ECF treatment | 184 | 40.10 | 97 | 67 | 2.55 | 1.63 | 3.98 | **<0.001** |
| Incurred other losses | 23 | 5.00 | 12 | 11 | 1.54 | 0.64 | 3.71 | 0.331 |

"OR" = Odds Ratio; allows for multiple responses
**Source: Authors' work (2013)**

**Table 5.** Results of the Partial Budget Analysis for ECF Vaccinating Households: Kshs per Cow per Year

| **GAINS Kshs per Cow per Year** | | **LOSSES Kshs per Cow per Year** | |
|---|---|---|---|
| 1. Extra Revenue (ER) in Kshs | 1. Extra Revenue (ER) Milk sales: 675 liters @ Kshs 60 = Kshs 40,500 | 2. Extra Costs (EC) in Kshs | Cost of ECF vaccine = Kshs 1,325 |
| 3. Costs Saved (CS) in Kshs | Vet consultations 4,000 | 4. Revenue Foregone (RF) in Kshs | RF = 0 (Zero) |
| | Vet drugs 1,400 | | |
| | Acaricide 2,400 | | |
| | CS = 5,400 | | |
| **Total Gain = (40,500 + 5,400)** | **= 45,900** | **Total Loss = (1,325 + 0) = 1,325** | |
| **Net Gain = (45,900 - 1,325)** | **= 44,575** | | |

Source: Authors' work (2013)

disease treatment and related charges. This net gain is a significant increase in a household income in a year.

Table 6 gives the results from partial budgeting for the ECF non-adopting dairy farming households in the study area.

Table 6 shows that the ECF non-vaccinating households incurred a net loss of Kshs 9,975 per cow per year by not adopting the ECFIM vaccine, primarily resulting from about

**Table 6.** Results of the Partial Budget Analysis for ECF Non-vaccinating Households: Kshs per Cow per Year

| GAINS | | LOSSES | |
|---|---|---|---|
| 1. Extra Revenue (**ER**) in Kshs | Extra Revenue (Zero) **ER**=0 | 2. Extra Costs (**EC**) in Kshs | EC1 = ECF treatment 4,000 |
| | | | EC2 = Vet Drugs 1,400 |
| | | | EC3 = Water for tick control 1,800 |
| | | | EC4 = Acaricide 2,400 |
| | | | EC5 = Milk loss due to ECF 2,700 |
| | | | **EC**=(EC1+EC2+EC3+EC4+EC5) =**Kshs 12,300** |
| 3. Costs Saved (**CS**) In Kshs | ECFIM vaccine = 1,325 | 4. Revenue Foregone (**RF**) in Kshs | **RF** = 0 (Zero) |
| | Labor = 1,000 | | |
| | **CS** = **2,325** | | |
| **Total Gain = (0 + (2,325) = (2,325)** | | **Total Loss = (12,300 + 0) = 12,300** | |
| **Net Gain = (2,325 - 12,300) = (-9,975)** | | | |

Source: Authors' work (2013

**Table 7.** Analysis of Variance (ANOVA) between various expenditure items in ECF control for vaccinating and non-vaccinating households

| | Vaccinated N=156 | | | | | Not Vaccinated N=109 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **n** | **Mean** | **Sd** | **Min** | **Max** | **N** | **Mean** | **Sd** | **Min** | **Max** | **P-value** |
| **Acaricide** | 91 | 6395.16 | 9445.4 | 100 | 72000 | 54 | 6795.74 | 7747.3 | 200 | 48000 | 0.727 |
| **Water** | 8 | 6430 | 6820.3 | 240 | 18000 | 6 | 7800 | 7503.6 | 2400 | 18000 | 0.096 |
| **Labour** | 58 | 20858.62 | 44774 | 1200 | 300000 | 28 | 56610.36 | 149174 | 1500 | 756000 | 0.564 |
| **Vet** | 6 | 12423.33 | 23587.6 | 200 | 60000 | 7 | 26211.43 | 52134.4 | 480 | 144000 | 0.179 |
| **Drugs** | 66 | 4019.85 | 7651.97 | 180 | 60000 | 50 | 10735.4 | 39418.4 | 300 | 276000 | 0.26 |
| **Syringe** | 11 | 2113.64 | 4417.97 | 50 | 12000 | 11 | 538.64 | 896.014 | 25 | 3000 | 0.946 |
| **Protective Clothing** | 35 | 3056.57 | 5690.6 | 200 | 24000 | 25 | 2956.4 | 5429.07 | 500 | 27000 | 0.388 |
| **Dipping** | 61 | 4588.36 | 8537.04 | 20 | 60000 | 37 | 3338.65 | 2455.49 | 30 | 8400 | 0.793 |

Source of Table 7: Authors' work (2013)

45% reduction in milk production due to ECF related sickness and stress, increased costs in the use of water and acaricides for tick control, labour and ECF treatment costs.

## Analysis of Variance (ANOVA) Results

Table 7 gives the results of the analysis of variance of between expenditure items for vaccinating and non-vaccinating households.

Even though the tests of statistical significance on the association between costs on various items used in ECF control, depending on whether the livestock was vaccinated against the ECF or not, as reflected in the parameters presented in Table 7, the field survey results suggest otherwise. When asked whether there were differences in milk yield between ECFIM vaccinating and non-vaccinating households, the households that had vaccinated against ECF stated that they had realized an average milk output of 7-10 liters per cow per day. On the other hand, the non-vaccinating household stated that they were realizing an average milk output of 5-7 liters per cow per day. These yields are consistent with expected yields for smallholder dairy farmers who keep cross-bred dairy cows. Based on differences in milk yields that translate into economic gains, this study established that ECF vaccinating households could realize up to 45% higher milk output over the yields realized by the non-vaccinating households.

## DISCUSSION, IMPLICATIONS AND RECOMMENDATION

The cost of the measures taken to control ticks in small scale farms is a financial burden to dairy farmers. In this study, the costs of acaricides application, which is the primary means of tick control, were found to range between Kshs. 1,500 and Kshs. 2,300. This range is consistent with the official estimate of the cost of acaricides application per adult animal at a range of from US$13 to

US$20 (MOLD, 2013).

In ECF disease management, the majority of farmers were found to be unilaterally administering treatment to their animals after they fall sick without informing their local veterinary officers about the disease incidences. However, the treatment was mostly conventional because the farmers would use modern veterinary drugs bought from Agro-vet shops. Nevertheless, a few of the farmers (less than 30% of the respondents) were found to be still using some traditional methods to treat ECF (that is, by using some herbs), even though the efficacy of these methods is highly questionable.

The losses associated with ECF disease include being unable to market dairy products at the estimated market price of Kshs 29,000, slaughtering of animals (salvage value; Kshs 40,000), milk loss (on average 64% production loss). These costs are heavy for small scale farmers. This level of losses is in agreement with Gachohi et al. (2012) who found that the economic losses due to ECF disease are more concentrated on small-scale resource-poor households who are left vulnerable with no other sources of primary household income.

Based on the Bennett (2003) economic model, the cost of ECF disease per household was calculated to be Kshs 34,875 per disease incidence. From the ANOVA analysis, there is no statistical association between whether the livestock was or was not vaccinated versus expenditure costs on the various ticks and ECF control items. Through the application of the partial budgeting technique to estimate the economic gains from investments in ECFIM and the related schedule of vaccinations of dairy animals as opposed to the use of the conventional ticks and ECF control through dipping in acaricides, it was found that the vaccinating households were realizing a net gain of Kshs 44,575 per cow per year from the adoption of the ECFIM vaccine while the ECF non-vaccinating households were incurring a net loss of at least Kshs 9,975 per cow per year by not adopting the ECFIM vaccine.

The net gain for the ECF vaccinating households resulted primarily from increased milk yield and reduced expenses on ECF treatment and related charges. The net loss for the ECF non-vaccinating households arose primarily from a 45% reduction in milk yield.

Based on the results from this study, small-scale dairy farmers in ECF endemic areas should abandon the traditional/conventional ticks and ECF control method of a weekly regime of dipping their livestock using acaricides and adopt the novel ECFIM vaccination regime because the latter method is more effective and is associated with significant increases in household incomes for those who adopt this ECF control method.

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**Competing interests**

The authors declare that they have no competing interests

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