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Supplementary Materials for

Livestock vaccinations translate into increased human capital and school attendance by girls

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SUPPLEMENTARY MATERIALS

Supplementary Text

Definition of economic models

We now summarize the theoretical framework more formally based on a seminal model of agricultural household production *(21-23)*. Let $\mathbf{V}$ represent demand for labor and non-labor inputs that may be allocated across activities to produce outputs $\mathbf{Q}$. Theory implies that input allocation decisions will be based on input and output prices, $\mathbf{P}^f$; fixed available productive assets, $\mathbf{K}$, such as available land; total time available to work; and other factors, $\mathbf{X}^f$, affecting production such as baseline (regional) disease prevalence and the household information set. These allocation decisions are represented by *input demand* and *output supply* relationships.

Input demand relationships are represented as

$$\mathbf{V}^* = \mathbf{V}\left(\mathbf{P}^f, \mathbf{K}, \mathbf{X}^f\right) \tag{S1}$$

In eq. (S1), if an input is used, its corresponding element in $\mathbf{V}$ is positive, and zero otherwise. Thus, input adoption decisions, which are central to this paper, are embedded in this general framework *(26)*. Importantly, changes or relative differences in the elements of $\left(\mathbf{P}^f, \mathbf{K}, \mathbf{X}^f\right)$ lead to factor input *substitution*. For example, the use of a current technology (e.g., acaracides) may be reduced with the advent of a new *substitute* (e.g., vaccine); or its use may increase if the new technology is a *complement* that increases the current technology's effectiveness.

Output supply relationships are a function of $\left(\mathbf{P}^f, \mathbf{K}, \mathbf{X}^f\right)$ both directly and through a household's chosen inputs

$$\mathbf{Q}^* = \mathbf{Q}\left(\mathbf{V}^*; \mathbf{P}^f, \mathbf{K}, \mathbf{X}^f\right) \tag{S2}$$

Under assumptions about household and market conditions that assure separability between household production and consumption decisions, the household makes production decisions to maximize income, and then makes consumption decisions to best satisfy their consumption preferences subject to their income, market prices, and other conditions [S1-S3]. These household consumption decisions imply a set of *consumer demand* functions

$$\mathbf{Z}^{*} = \mathbf{Z}\left(Y^{*}, \mathbf{P}^{c}, \mathbf{X}^{c}\right) \tag{S3}$$

where $\mathbf{Z}$ are consumed goods dependent upon full household (net, disposable) income, Y^{*}, market prices, $\mathbf{P}^{c}$, and other environmental factors, $\mathbf{X}^{c}$. Household net income, Y^{*}, contains two income streams of particular interest: sale and/or in-home use of outputs $\mathbf{Q}^{*}$, and off-farm market labor and investment returns, which are available for consumption and reinvestment.

As in the production setting, changes in elements of $\left(Y^{*}, \mathbf{P}^{c}, \mathbf{X}^{c}\right)$ can lead to substitution effects in consumption. But on the demand side there are also *income effects*, which together manifest as changes in the consumption bundle $\mathbf{Z}^{*}$. For example, an increase in the price of meat may lead to less consumption of meat and more consumption of maize (i.e., substituting less meat for more maize consumption). Increases in income, from more off-farm income or increased sales of farm products, may enable households the opportunity to purchase more goods for current consumption (indicating a positive income effect). A reduction in the market price of milk may lead a household milk producer to consume more milk, rather than sell it, or in the long-run reduce investment in milk production and instead invest in the production of crops or other livestock.

The theoretical model provides a foundation to test hypotheses about economic outcomes of pastoral households making ECF management decisions. These hypotheses are specified and tested with empirical regression models.

Empirical models

The structure of eqs. (S1) through (S3) provide guidance for estimation. With the insertion of additive (unobserved) disturbance terms $\boldsymbol{\varepsilon} = \left(\boldsymbol{\varepsilon}_{V}, \boldsymbol{\varepsilon}_{Q}, \boldsymbol{\varepsilon}_{Z}\right)$, eqs. (S1) through (S3) can be characterized as statistical regression equations. Notice in particular that while inputs $\mathbf{V}^{*}$ in eq. (S1) are assumed to be determined by exogenous variables (determined outside the household environment or systems of equations), $\mathbf{Q}^{*}$ and $\mathbf{Z}^{*}$ in eqs. (S2) and (S3) include $\mathbf{V}^{*}$ and Y^{*}, which are determined endogenously by households based on their management decisions. This fact has important implications for estimating eqs. (S2) and (S3). It implies that direct statistical relationships (e.g. correlations) between vaccination rates and livestock outcomes such as milk production or livestock death are likely to be misleading. To illustrate, it makes sense to adopt ECF vaccination practices only when ECF infection risk is positive. Therefore, an estimate of a simple correlation between household ECF vaccination rates and ECF incidence across herds might be positive (or at least biased upward) even if ECF vaccination were actually reducing ECF incidence.

Regression analysis applied to $\mathbf{Q}^*$ and $\mathbf{Z}^*$ must account for the endogeneity of the vaccination decision in order to retrieve statistically consistent parameter estimates. We use a standard two-stage *instrumental variable* estimation approach to account for endogeneity of vaccination adoption and use *(25)*. This approach can be described as follows to account for endogenous input use $\mathbf{V}^*$ in the production eq. (S2) for $\mathbf{Q}^*$:

Stage 1. Estimate first-stage regressions that represent the household's vaccination adoption and management decisions, $\mathbf{V}^*$, and generate predicted values, $\hat{\mathbf{V}}$, from these regressions (note that this first-stage regression is of interest in its own right to understand ECF vaccine adoption and use).

Stage 2. Estimate a second-stage treatment effect regression for, say, $\mathbf{Q}^*$ in which the observed vaccination adoption variable $\mathbf{V}^*$ is replaced by the predicted value $\hat{\mathbf{V}}$ from the first-stage regression.

Replacing observed $\mathbf{V}^*$ with $\hat{\mathbf{V}}$ in the second-stage regressions reduces or removes correlation between $\mathbf{V}^*$ and the regression disturbance term that follows structurally from the endogeneity of input allocation decisions (leading to inconsistent regression parameter estimates if ignored). This two-stage instrumental variable approach is among the most effective ways to construct an instrument for reducing or removing statistical inconsistency following from regressor endogeneity, and is a mainstay of econometric analysis *(25)*.

A similar relationship exists between $\mathbf{Z}^*$ and household income Y^*, except for theoretical issues that lead to a slightly different strategy for modeling $\mathbf{Z}^*$ (eq. (S3)). The first is that our maintained hypothesis of separability between production and consumption implies that while Y^* is determined by the household, it is exogenous with respect to consumption decisions. As such, consistent (and more efficient) estimation of the consumption regressions can be carried out with the original income measure (rather than an instrument for it). Second, we do not actually have a full income measure reported in our dataset; we have a measure of off-farm income. As such, we include both off-farm income (from the questionnaire) and $\hat{\mathbf{V}}$ to instrument for $\mathbf{V}^*$ as a proxy to capture the income variation that results from differences in input use. That is, we estimate $\mathbf{Z}^* = \mathbf{Z}\left(Y^0, \hat{\mathbf{V}}, \mathbf{P}^c, \mathbf{X}^c\right)$ in lieu of eq. (S3) where Y^0 is off-farm income. To the extent that differences in chosen inputs $\mathbf{V}^*$ affect consumption decisions, it most likely does so indirectly through its income effect.

The variables $\mathbf{V}^*, \mathbf{Q}^*$, and $\mathbf{Z}^*$ each represent potentially numerous regression relationships characterizing the full set of inputs, outputs, and consumption goods involved in household decisions. However, any one of these regressions, when estimated separately, can provide statistically consistent (though not fully efficient) parameter estimates *(25)*. This fact allows us to focus on and consistently estimate only the subset of household production and consumption relationships most central to the question of EFC vaccine adoption and for which we have sufficient data.

The economic effects of ECF and its treatment affect more than just livestock and herd productivity, however. ECF productivity losses reduce household income (whether or not livestock products are sold or consumed in house), and income losses may affect the household's capacity to purchase other consumption goods, or to invest in other durable assets, education, or human health maintenance and care. Based on prior expectations and data availability, we examine the effects of vaccination and other factors on education, food, and human health expenditures.

Given the above discussion, regressions are reported for three response variables of interest:

1. Inputs ($\mathbf{V}^*$): vaccination adoption (*VaccForECF*), the number of adult, 1-2 year olds (bullocks and heifers), and calves vaccinated (*NumVaccAdult NumVaccHfrBlk NumVaccCalves*), and the number of antiobiotic treatments applied for ECF infections (*NumAntbiotTrtmt*).
2. Outputs ($\mathbf{Q}^*$): cow milk production, (*AvgMilkPerCow*), and ECF deaths for adult, 1-2 year olds and calves.

3. Consumption expenditures ($\mathbf{Z}^*$): education expenditures (*EducationXpend*), human health expenditures (*HumHlthXpend*), and food expenditures *(FoodExp)*

There are several distinguishing features of the dependent variables that affect appropriate regression specification. Their values are all non-negative, there are a substantial number of zeros in the data, and the distributions are highly right-skewed. In addition, some variables are integer count values (e.g., the number of vaccinations in a herd and the number of ECF-related deaths). We treat these as integers in their respective regression specifications. Other variables are represented as continuous values. Consequently, we utilize variable transformations, limited dependent variable regressions, and count regression models as needed.

For all regression results the effects of continuous variables on outcomes (dependent variables) are reported as elasticities, which is the percentage change in the dependent variable in response to a one percent change in the explanatory variable, or in mathematical terms, $\eta_{YX} = \frac{dY}{dX}\frac{X}{Y}$, where η_{YX} represents the elasticity of outcome Y with respect to an explanatory variable X. Unless otherwise noted the reported elasticities are evaluated at the means of the data used in the regression. Parameter estimates cannot be interpreted as marginal effects in these count regression models *(25)*. For indicator regressors (binary variables taking the value 0 or 1), the parameter shown represents an approximate percentage effect of the indicator variable, I, in response to a change from zero to one $\frac{Y|(I=0,\mathbf{X}) - Y|(I=1,\mathbf{X})}{Y|(I=0,\mathbf{X})}$ where $\boldsymbol{X}$ here represents the other covariates being held constant.

Robustness and Limitations

To test robustness of Poisson count models of ECF vaccine adoption reported in table S3, negative binomial regression models were also estimated. Results indicate the presence of overdispersion for models S1-S3 in table S3. Nevertheless the Poisson and negative binomial predictive values remain very similar. To avoid misspecification problems from an individual model, single equation Poisson regression models were estimated. See *(27)* for more details on robustness and prediction of the Poisson model. Over the sample the average number of vaccinated calves, yearlings, and adults were 3.99, 6.93, and 9.86 respectively. The average predicted values by the Poisson model were 3.86, 6.78, and 9.05.

Income from household-raised livestock is not accounted for in off-farm income, and so is not directly accounted for in table S5 regressions. Predicted ECF vaccinations are included in the regression to proxy income from cattle. To test robustness of the assumption that ECF vaccinations translate through an income channel, we provide an alternative specification by replacing predicted ECF vaccination with predicted net income from livestock. We construct net income or profit from livestock revenue (cattle, sheep, and goats) at given market level prices less production costs. Profit is then regressed on the total number of sheep and goats, donkeys, and cattle losses from non-ECF causes. We use this regression to predict profit, *LivestockProfit^*. To control for potential endogeneity of livestock profit, *LivestockProfit^* is used as an instrumental variable in the expenditure regression models replacing the number of ECF vaccinated cattle reported in table S5. The results of the modified expenditure regressions (table S7) are similar to and consistent with the results in table S5. This provides evidence that additional ECF vaccinations are translated through income effects and congruent with higher household income. The elasticity of expenditures associated with *LivestockProfit^* is positive in all cases, and significant for education, food, and human health, suggesting that the value of on-farm productivity (holding off-farm incomes constant) significantly and positively impacts household expenditures. While the positive and significant impact for education and food is robust across competing model specifications examined in this paper, mixed effects are observed for human health expenditures. In contrast, off-farm income remained significant and positive for human health expenditures across the competing model specifications.

There are several limitations of this study. First, all data collected and used in this study are based on household response and recall. It was not possible to verify reported ECF incidence, livestock deaths, or other outcomes over the last year as reported by respondents. Thus, the accuracy of our analysis is limited by precision and accuracy of these household responses (and the survey enumerators). Second, this dataset includes data only on current status and recall information for the past one year, and is not a panel dataset. Third, we do not have any information on the regional prevalence or incidence of ECF beyond this dataset. While we do have survey information on ECF incidence for the households sampled, a lack of more complete epidemiological information on ECF burden limits the extent to which we can make inferences about how vaccination benefits would differ under varying ECF prevalence or pathogenic species of Theileria *(12)*. Further, we do not have sufficient data to estimate the longer-run effects of ECF vaccination on ECF prevalence. Finally, while we believe this study is an important contribution in assessing direct and indirect impacts of livestock vaccination at the household level, it is not a complete definitive study of vaccination at the microeconomic or macroeconomic levels. Future studies exploring richer data sets and alternative populations, applying competing modeling approaches, investigating vaccine delivery, accounting for joint production as well as spillover effects within and across households, exploring intra-household decision making, and estimating different measures of private and social returns are important to understanding problems and impacting goals.

table S1. Descriptions of variables used in analysis.

variable name	variable label [Questionnaire question number]
NumAdultCattle	Number of adult cattle [164]
NumHfrBlk	Number of 1-2 year olds (heifers and bullocks) [162+163]
NumCalves	Number of calves [161]
NumCattle	Total number of cattle [sum(161-164)]
FracXbreed	Fraction of herd cross-breed [42/ NumCattle]
AvgMilkPerCow	Average amount of milk per cow [Q053÷Q060]
VaccForECF	Do you vaccinate for ECF? (Y/N) [Q007]
NumVaccAdult	Number of ECF vaccinated adult cattle [224]
NumVaccHfrBlk	Number of ECF vaccinated 1-2 year olds [222+223]
NumVaccCalves	Number of ECF vaccinated calves [221]
FracVaccAdult	Faction of adult cattle vaccinated for ECF [224/164]
NumAntbiotTrtmt	Number of antibiotic treatments for ECF in 12 mo. [sum Q217-Q221]
ECFdeathsAdult	Number of adult cattle that died from ECF in last year [216]
ECFdeathsHfrBlk	Number of 1-2 year olds that died from ECF in last year [Q214+Q215]
ECFdeathsCalves	Number of calves that died from ECF in the last year [213]
ECFdeathsAll	Total ECF deaths this year = [Q213+Q214+Q215+Q216]
VaccInfo:Farmers	Vaccine info source: Farmers (Y/N) [001#5853]
VaccInfo:NGO	Vaccine info source: NGO service providers (Y/N) [001#5850]
VetServ:Comunty	Vet service provider: Community animal health workers (Y/N)[003#5978]
VetServ:Agroshop	Vet Service provider: Medicine store/agroshop (Y/N)[003#5981]
NumTickTrtNVac	How many tick treatments do you apply per month, unvaccinated cattle [015]
NumTickTrtVacc	How many tick treatments do you apply per month, vaccinated cattle [016]
GrazePractChng	Do you change grazing practices due to perceived ECF risk? (Y/N) [030]
MissedWorkDays	Number of missed work days due to ECF care of livestock [027]
MilkReductnECF	If ECF reduces milk prod., by how many liters/day per infected cow? [021]
SellECFMilk	Do you sell milk from an ECF-infected cow? (Y/N) [022]
CnsumeECFMilk	Do you consume milk from an ECF-infected cow? (Y/N) [23]
HouseholdSize	# household members = [sum(Q80,Q81,Q82,Q85,Q86,Q89,Q90,Q91,Q92)]
NumSchoolAge	# school age children = [sum(Q81,Q82,Q85,Q86)]
SavingsAccount	Does any household member maintain savings account? (Y/N)[128]
ChldUnder5milk	133. How many children under 5 years old drink milk daily? [133]

EducationXpend	Household expenditure on education last term (4 months.,1000Ksh) [160]
HumHlthXpend	Household expenditure on human health care, last 4 months (1000Ksh) [159]
FoodXpend	Estimated as the sum of staple food expenditures (market prices times quantities reported for maize, means, rice, beef, and sheep/goat meat consumed)[133-156]
District	1= Kajiado&Isinya,2= Narok,3=Transmara,4=All other (northern)t districts.
Q084Boysatprs	How many boys are attending primary school?
Q087Grlsatscs	How many girls are attending secondary school?
Q088Boysatscs	How many boys are attending secondary school?
OffFarmIncome	Household Income not from crops or livestock. (Ksh:1= 0-5,000; 2=5,001-10,000; 3=10,001-20,000; 4=20,001-40,000, 5=40,001-80,000; 6=80,000+).

table S2. Summary statistics for variables used in the regressions.

variable	mean	sd	p50	N
NumAdultCattle	65.892	90.191	37	461
NumHfrBlk	23.389	33.794	13	460
NumCalves	18.403	29.615	10	462
NumCattle	107.335	137.03	62	457
FracXbreed	0.408	0.445	0.141	456
AvgMilkPerCow	1.916	2.661	1	451
VaccForECF	0.39	0.488	0	469
NumVaccAdult	9.857	28.759	0	462
NumVaccHfrBlk	6.933	19.27	0	462
NumVaccCalves	3.987	15.143	0	462
FracVaccAdult	0.158	0.316	0	458
NumAntbiotTrtmt	17.086	22.739	10	453
ECFdeathsAdult	1.16	2.502	0	457
ECFdeathsHfrBlk	0.843	1.687	0	458
ECFdeathsCalves	1.148	2.03	0	458
ECFdeathsAll	3.158	4.755	2	455
VaccInfo:NGO	0.179	0.384	0	469
VaccInfo:Farmers	0.173	0.378	0	469
VetServ:Comunty	0.151	0.359	0	469
VetServ:Agroshop	0.079	0.27	0	469
MissedWorkDays	4.314	10.028	0	431
EducationXpend	44.26	66.896	20	459
HumHlthXpend	11.942	21.558	5	459
MilkReductnECF	0.813	1.224	0.5	446
FoodXpend	2.701	6.626	2.001	454
SellECFMilk	0.235	0.425	0	442
CnsumeECFMilk	0.524	0.5	1	439
NumTickTrtmts	3.814	9.325	4	451
GrazePractChng	0.336	0.473	0	426

HHSize	15.115	10.813	12	451
NumSchoolAge	5.282	4.714	4	457
GrazePractChng	0.336	0.473	0	426
SavingsAccount	0.69	0.463	1	461
ChldUnder5milk	2.857	1.736	3	456
district	1.753	0.829	2	469
Q084Boysatprs	1.828	2.069	1	464
Q087Grlsatscs	0.488	0.885	0	463
Q088Boysatscs	0.682	0.995	0	462
OffFarmIncome	2.325	1.685	1	464

table S3. Determinants of ECF vaccine adoption and antibiotic treatment.

	Model S0	**Model S1**	**Model S2**	**Model S3**	**Model S4**
	NumVaccCat	***NumVaccAdult***	***NumVaccHfrBlk***	***NumVaccCalves***	***NumAntbiotTrtmt***
NumCattle[a]	0.327***	0.235***	0.375***	0.562***	0.388***
FracXbreed[a]	0.457***	0.490***	0.443***	0.665***	0.080
MilkReductnECF[a]	0.072***	0.111***	0.044	0.043*	0.063*
SellECFMilk[b]	-0.037	-0.078	-0.043	-0.127	0.002
CnsumeECFMilk[b]	-0.271*	-0.256	-0.217	-0.298	-0.016
NumTickTrtmts[a]	-0.081	-0.540	0.390	0.060	-0.271
HHSize[a]	-0.062	-0.418	-0.023	-0.210	-0.146
NumSchoolAge[a]	0.397	0.860**	0.243	0.335	0.236
GrazePractChng[b]	0.055	0.056	0.060	-0.054	-0.064*
SavingsAccount[b]	-0.019	-0.167	0.123	-0.027	0.194*
ChldUnder5milk[a]	-0.055	-0.010	0.083	-0.138	0.049
VaccInfo:NGO[b]	0.048	0.086*	0.051	0.022	0.062*
VaccInfo:Farmers[b]	0.032	0.014	0.061	0.106**	0.033
VetServ:Comunty[b]	-0.113	-0.375***	0.028	-0.019	-0.059*
VetServ:Agroshop[b]	-0.111**	-0.144***	-0.091**	-0.147*	-0.067***
5k<OffFarmIncome ≤ 10k[c]	0.864***	1.130**	0.512	1.449***	0.015
10k<OffFarmIncome≤ 20k[c]	0.432	0.973***	-0.407	0.444	-0.053
20k<OffFarmIncome≤ 40k[c]	0.845**	0.826**	0.871**	0.344	-0.377*
40k<OffFarmIncome≤ 80k[c]	0.822**	0.704	0.761**	1.193**	0.100
80k<OffFarmIncome[c]	0.198	0.599	0.211	-1.741	-0.174
District 2[c]	0.005	0.446	-0.348	0.053	0.115
District 3[c]	1.741***	-1.805***	-1.689***	-0.944*	0.058
District 4[c]	1.413**	-1.000*	-1.666**	-1.562***	-0.625*
*NumVaccAdult^*[a]					0.006
*NumVaccHfrBlk^*[a]					-0.111***
*NumVaccCalves^*[a]					0.006
constant	1.646**	0.971	-0.079	-0.578	2.316***
N	356	356	356	356	348
R^{2,}, Pseudo-R^2	0.45	0.44	0.42	0.50	0.33

[a] Elasticities (continuous regressors); [b] Percent change (binary regressors); [c] Coefficients; ^Predicted values.

*10%, **5%, ***1% level of significance. Model S0 – total number of cattle vaccinated for ECF, Model S1- number of adult cattle vaccinated for ECF, Model S2- number of 1-2 year olds vaccinated for ECF, Model S3- number of calves vaccinated for ECF, Model S4 – antibiotic treatments. Poisson regression with robust standard errors.

table S4. Impact of ECF vaccination on milk production and prevention of mortality.

	Model S5	**Model S6**	**Model S7**	**Model S8**	**Model S9**
	AvgMilkPerCow	***ECFdeathsAll***	***ECFdeathsAdult***	***ECFdeathsHfrBlk***	***ECFdeathsCalves***
FracVaccAdult[a]	0.080***				
NumVaccCattle^[a]		-0.056*			
NumCattle[a]		0.239***			
NumVaccAdult^[a]			0.010		
NumAdultCattle[a]			0.089		
NumVaccHfrBlk^[a]				0.004	
NumHfrBlk[a]				0.148**	
NumVaccCalves^[a]					-0.086***
NumCalves[a]					0.228***
NumTickTrtmts[a]	0.147	0.201	0.103	-0.077	0.557*
FracXbreed[a]	0.187***	-0.173***	-0.265**	-0.153*	-0.118*
GrazePractChng[b]	0.092**	0.093*	0.068	0.198***	-0.003
District 2[c]	-1.412***	-0.261	-0.506*	-0.053	0.162
District 3[c]	0.160	-0.419**	-0.530**	-0.161	-0.470*
District 4[c]	0.766***	-2.816***	-2.527***	-2.344**	-15.404***
Constant	-0.190	1.089***	0.495	-0.197	-0.378
N	386	349	351	352	352
R^2, Pseudo-R^2	0.42	0.09	0.05	0.08	0.08

[a]Elasticities (continuous regressors); [b]Percent change (binary regressors); [c]Coefficients; ^ represents predicted value.

*10%, **5%, ***1% level of significance. Model S5 – milk production, Model S6 – all ECF deaths, Model S7 – ECF deaths of adult cattle, Model S8 – 1-2 year old deaths due to ECF, and Model S9 – calf deaths due to ECF. Model S5 - ordinary least squares with robust standard errors. Dependent variable transformed by natural logarithm. Models S6 to S9 - Poisson regression with robust standard errors.

table S5. Parameter estimates for expenditures on education, human health, and food.

	Model S10 ***EducationXpend***	**Model S11** ***HumHlthXpend***	**Model S12** ***FoodXspend***
NumVaccCattle^[a]	0.088**	0.042	0.056***
HHSize[a]	0.701***	0.351***	0.326***
ChldUnder5milk[a]	-0.231	0.067	0.074
5k<OffFarmIncome ≤ 10k[b]	0.091	0.044	-0.083
10k<OffFarmIncome≤ 20k[b]	0.498***	0.456***	0.182*
20k<OffFarmIncome≤ 40k[b]	0.549*	0.573**	0.108
40k<OffFarmIncome≤ 80k[b]	0.707**	0.350*	0.204***
80k<OffFarmIncome[b]	1.005***	0.707**	0.145
District 2[b]	0.104	0.475***	0.032
District 3[b]	1.246***	0.604***	0.087
District 4[b]	1.255***	0.856***	0.009
constants	1.916***	0.823***	0.184**
N	346	350	346
$R^{2,}$, Pseudo-R^2	0.26	0.15	0.27

[a] Elasticities (continuous regressors); [b] Coefficients (binary regressors). ^ represents predicted value.

*10%, **5%, ***1% level of significance. Model S10 – education expenditure, Model S11 – health expenditure, Model S12 – food expenditure. Models S10 to S12 - ordinary least squares with robust standard errors. Dependent variables transformed by natural logarithm.

table S6. Poisson regression models of children in school correlated with ECF deaths or vaccinated adult cattle.

	Model S13	**Model S14**	**Model S15**
	Q088Boysatscs	***Q084Boysatprs***	***Q087Grlsatscs***
Ecfdeathspc	-1.060*	-1.357***	
FracVaccAdult			0.502**
constant	-0.324***	0.686***	-0.827***
N	447	449	456

*10%, **5%, ***1% level of significance. Model S13 – boys in secondary school, Model S14 – boys in primary school, Model S15 – girls in secondary school.

table S7. Parameter estimates for expenditures on education, human health, and food with predicted livestock profit.

	Model S16 ***EducationXpend***	**Model S17** ***HumHlthXpend***	**Model S18** ***FoodXspend***
LivestockProfit^[a]	0.029***	0.011*	0.012*
HHSize[a]	0.665***	0.302***	0.337***
ChldUnder5milk[a]	-0.200	0.097	-0.032
5k<OffFarmIncome ≤ 10k[b]	0.137	0.138	-0.071
10k<OffFarmIncome≤ 20k[b]	0.509***	0.459***	0.108
20k<OffFarmIncome≤ 40k[b]	0.873***	0.609***	0.140
40k<OffFarmIncome≤ 80k[b]	1.061***	0.511***	0.257***
80k<OffFarmIncome[b]	1.062***	0.983***	0.306**
District 2[b]	0.151	0.354***	0.040
District 3[b]	1.204***	0.579***	0.101
District 4[b]	1.232***	1.016***	0.033
constants	1.883***	0.842***	0.279**
N	401	410	406
$R^{2,}$, Pseudo-R^2	0.26	0.17	0.21

[a]Elasticities (continuous regressors); [b]Coefficients (binary regressors). ^ represents predicted value.

*10%, **5%, ***1% level of significance. Model S16 – education expenditure, Model S17 – health expenditure, Model S18 – food expenditure. Models S16 to S18 - ordinary least squares with robust standard errors. Dependent variables transformed by natural logarithm.