Economic Consequences of Foot-and-Mouth Disease Outbreak in Northern Tanzania

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Selected Poster prepared for presentation at the
2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Joint Annual Meeting, San Francisco, CA, July 26-28

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Introduction

- Livestock disease incidences can result in significant impedance to people's livelihoods and food security.
- While available literature on Foot-and-Mouth Disease (FMD) economic impacts have looked at the costs incurred due to outbreaks at an aggregate level, microeconometric studies investigating impacts of such outbreaks on individual livestock-owning households are severely limited.
- To inform policy towards sustainable interventions it is imperative to better understand disease implications at the local level.
- In this study, we demonstrate that FMD prevention in livestock-dependent communities in Tanzania would reduce the FMD burden and increase livestock production opportunities.

Objectives

- The primary objective of this study was to quantify economic impacts of FMD on traditional livestock production systems in Tanzania (including agro-pastoral and pastoral households, and rural small holders).
- Specifically, we estimate the impacts of FMD outbreak, vaccination, and demographic factors on milk production, traction, livestock sales, and human capital investment that include expenses on child education and human health.

Theoretical Framework

- Let y_p and y be outputs under no disease outbreak and that under an outbreak, respectively, such that $y < y_p$.
- Let p be expected price of output such that $p = (1-\delta(v))\, p_w + \delta(v)\, p_r$ where the disease free product receives the world price p_w and the disease infected product receives the regional price p_r. δ = probability of disease occurrence which is a function of vaccination (v); $\delta = 1$ implies disease-endemic, $\delta = 0$ implies disease-free.
- Let $0 \le v \le 1$ where $v = 0$ implies none of the cattle in the herd is vaccinated and $v = 1$ implies fully vaccinated herd. Assume that the disease outbreak is a decreasing function of v, i.e., $\delta_v(v) < 0$.
- Expected cost of production is assumed to be of additive form:

$$\tilde{C}(y_p, v, U(v)) = (1-\delta(v))C(y_p, v) + \delta(v)\hat{C}(y, v^e, U(v))$$

where v^e is emergency vaccination and U denotes disease clean up.

- The expected output, Y, is given as: $Y = (1-\delta(v))\, y_p + \delta(v)\, y$
- Farm maximizes profit by choosing the optimal level of v:

$$\underset{v}{Max}\ \pi = \left[p_w(1-\delta(v)) + p_r\delta(v)\right]\left[(1-\delta(v))y_p + \delta(v)y\right] - \left[(1-\delta(v))C(y_p, v) + \delta(v)\hat{C}(y, v^e, U(v))\right]$$

- The first-order condition implies that expected marginal revenue from vaccination equal its expected marginal cost:

$$\underset{-}{\delta_v(v)}\left[\underbrace{p(y-y_p)}_{-} + \underbrace{Y(p_r - p_w)}_{-}\right] = \left[\left\{\underbrace{(1-\delta(v))C_v(\cdot)}_{+} \underbrace{-\delta_v(v)C(\cdot)}_{+}\right\} + \left\{\underbrace{\delta_v(v)\hat{C}(\cdot)}_{-} + \delta(v)\left\{\underset{+}{\hat{C}_{v^e}(\cdot)} \times \underset{-}{v_v^e} + \underset{+}{\hat{C}_U(\cdot)} \times \underset{-}{U_v(v)}\right\}\right\}\right]$$

- The expected cost goes up with prophylactic vaccination while it goes down with vaccinating the residual herd. Besides, three effects are manifested: productivity effect, price effect (driven by quality differences), and income effect.

Data and Empirical Methods

- A household survey was conducted in 78 households of northern Tanzania, where FMD is endemic.
- Data were collected on household demographics, crop and livestock production, and losses due to livestock diseases with a focus on FMD.
- Various specifications (OLS, Logit, Tobit) of milk production, traction, cash income from livestock sales, and human capital development were estimated.

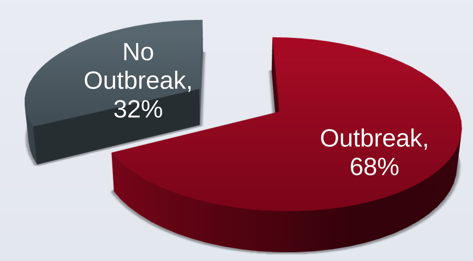

Fig 1a. FMD Outbreak Events

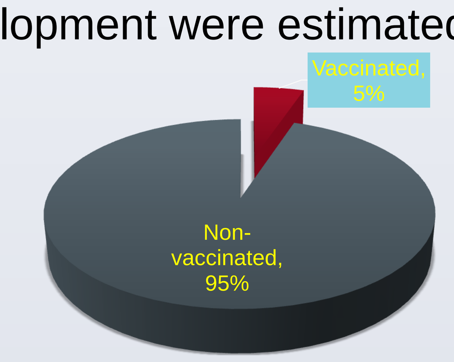

Fig 1b. Proportion of Households with Vaccinated Cattle

Results

Table 1. OLS coefficients (std. errors) for milk production functions

Variables	Model 1	Model 2	Model 3	Model 4
Dep. variable	Ln (Milk produced, ltr/day)		Ln (Milk produced / cow, ltr/day)	
No. of cows	0.0044***	0.0043***		
	(0.0013)	(0.0012)		
Exotic	0.3312	0.3558	0.8573***	0.8343***
	(0.3434)	(0.3396)	(0.2076)	(0.2006)
FMD	-0.1179	-0.2322	-0.3312*	-0.3999**
	(0.2526)	(0.2532)	(0.1780)	(0.1829)
Reported vacc.	0.5415	0.9993**	0.8144***	1.0303***
	(0.4360)	(0.4928)	(0.2474)	(0.1771)
Intercept	2.8278***	2.1465*	0.1057	-0.3611
	(0.9155)	(1.0792)	(0.1454)	(0.5866)

*10%, **5%, ***1% level of significance. Regional dummies were not significant.

- Exotic breeds gave more milk than local breeds, as expected. FMD had significantly negative impact on milk produced per cow (30% less milk produced per cow).
- Vaccinated cows yielded 145% more milk than non-vaccinated cows.
- In a separate estimation, the odds of reduction in traction productivity due to FMD was 10 - 27 times higher than when FMD outbreak did not occur (results not shown).

Impact on livestock sales:

- Households that realized FMD outbreak had about 220,000 TZS (≈110 US$) less cash income generation from livestock sales in the past four months of the survey.
- Households that had income from crops had higher revenue from livestock sales as well, which demonstrated a complementary relationship across sectors.
- Vaccination was barely significant.
- While sales varied slightly across regions, size of herd and disease treatment cost were not significant in the models.

Table 2. Estimated marginal effects for expenses on education and health over the past four months of the survey.

Variables	Model 5	Model 6	Model 7	Model 8
Dependent variable	Educational expense (TZS per child)		Health expense (TZS per capita)	
Income effects				
FMD in past 4 months	77106	48743	-7462**	-6091*
	(49896)	(55983)	(3153)	(3257)
Reported vaccination	94900**	123456*	-7322**	-9134***
	(46654)	(68694)	(3295)	(2267)
Log of herd size	29393		11773**	12048**
	(26798)		(4870)	(4859)
Crop income		79737*	NS	NS
		(44310)		
Demographic effects				
Household size	12162	21203*	-1000***	-1021***
	(8170)	(11709)	(364)	(359)
No. of school going child	-48308*	-68945*		
	(26313)	(35150)		
Age of household head	5227*	3474	-48	
	(2766)	(2496)	(121)	
Primary education of HH	160900*	160009**		1749
	(80483)	(74470)		(2996)
Secondary educ. of HH	484945	513906*		14814
	(305818)	(294172)		(10574)
College education of HH	635728***	639117***		22268***
	(99410)	(98563)		(7546)
Regional effects				
Significant?	NO	NO	YES	YES

*10%, **5%, ***1% level. NS = Not significant. HH = Household head. Robust standard errors in parentheses.

- FMD outbreak resulted in lower health expenses, so did vaccination. This might be due to more milk consumption because of curbed milk sales during the outbreak.
- Vaccination of herd and income from crops were associated with higher expenses in child education.
- Household head's education level had generally a positive impact (higher) on expenses in child education and human health.

Conclusion and Policy Implications

- This study adds to the scanty literature on household-level impacts of FMD in endemic settings, providing evidence that the FMD burden on traditional Tanzanian communities is considerable.
- A general negative impact of FMD and positive impact of vaccination on farm productivity, cash income generation, and human capital investment suggesting implications for disease prevention and cattle vaccination policies.