

Institution: University of Glasgow (UofG)		
Unit of Assessment: UoA 6 (Agriculture, Veterinary and Food Sciences)		
Title of case study: Improving surveillance and control of livestock diseases in Tanzania with community, government and industry partners		
Period when the underpinning research was undertaken: 2011–2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
(1) Prof. Sarah Cleaveland	(1) Professor	(1) 2008–present
(2) Dr Tiziana Lembo	(2) Research Associate; Lecturer; Senior Lecturer	(2) 2007–17; 2017–18; 2018–present
(3) Dr Taya Forde	(3) Research Fellow	(3) 2015–present
(4) Dr Richard Reeve	(4) Research Fellow; Reader	(4) 2005–17; 2017–present
(5) Prof. Dan Haydon	(5) Professor	(5) 2007–present
(6) Prof. Katie Hampson	(6) Research Fellow; Reader; Professor	(6) 2008–15; 2015–20; 2020–present
(7) Dr Roman Biek	(7) Lecturer; Senior Lecturer; Reader	(7) 2007–13; 2013–16; 2016–present
Period when the claimed impact occurred: 2014–present		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact		
Tanzania has the third largest livestock population in Africa (~30 million cattle), supporting ~70% of households. Nonetheless, economic development and social welfare are constrained by livestock diseases such as foot-and-mouth disease (FMD) and anthrax, particularly affecting livestock-dependent communities with few links to policy makers. UofG research on FMD and anthrax has improved disease surveillance capacity, and informed disease management at community and national levels. Specifically, this research has (1) supported the Tanzanian Government's anthrax and FMD management policies; (2) shaped components of the Tanzanian Livestock Modernization Initiative (2015–2020); (3) enabled Tanzania to join a United Nations FAO global initiative for FMD control; and (4) delivered an anthrax control strategy within the Ngorongoro District.		
2. Underpinning research		
UofG researchers have identified anthrax and FMD as the diseases of most concern across traditional livestock production systems in Tanzania. Their research quantified the occurrence of, and losses caused by, these diseases (disease burden), and generated the epidemiological evidence and local connectivity to manage their impacts (targeted control).		
Understanding the burden of livestock disease		
FMD is a highly contagious, although not typically lethal, viral disease; however, the household-level burden in Tanzania was not known. UofG-led socioeconomic research was the first to quantify this burden comprehensively [3.1]. Effects on productivity included: an average 67% decrease in milk yields (a key protein source); a 27% reduction in income from livestock sales (with a concomitant 25% decrease in expenditure on healthcare and education); and increased costs to mitigate these losses, such as keeping high livestock numbers and antibiotic usage. Nonetheless, only 5% of households reported vaccinating livestock against FMD [3.1].		
Anthrax is a zoonotic disease caused by the bacterium <i>Bacillus anthracis</i> ; it is lethal to livestock and potentially fatal to humans. Dogs can be exposed to anthrax via infected carcasses, but are not susceptible to the disease and so can act as an indicator species. UofG research showed, for the first time, that antibody testing on domestic dogs offers a safe surveillance tool for anthrax [3.2]. This UofG-led, community-based surveillance approach enabled anthrax to be detected in remote areas and included an improved staining technique, developed by UofG, for use with on-site microscopy [3.3]. In addition, a broad communication network was established, comprising a WhatsApp working group of 32 community health and animal health workers; district-level veterinary and medical officers; and UofG researchers [3.4]. This surveillance work demonstrated that most sudden livestock deaths are due to anthrax, which causes losses		

exceeding monthly household incomes. Other daily impacts of this disease included human morbidity and mortality, as well as high costs from seeking treatment, particularly in remote areas [3.4].

Targeting control of livestock disease

Epidemiological studies of **FMD**—led by UofG in collaboration with the Pirbright Institute (UK), Tanzania Wildlife Research Institute and Sokoine University of Agriculture (Tanzania)—revealed the existence of four dominant FMD virus types in Tanzania. The UofG surveillance platform for FMD established an unprecedented biobank of these viruses (from 0 in 2011 to >100 by 2020), which can be used to inform vaccine development and vaccination strategies [3.1]. In a landscape where livestock and wildlife co-exist, this research showed that FMD in cattle is driven by livestock-related factors, including management practices, herd size and new additions to the herd, rather than by wildlife-related factors [3.1]. Furthermore, a distinct FMD virus type is dominant and unchanging during outbreaks in both Tanzania and Kenya, suggesting that type-specific vaccination could be used to mitigate outbreaks. Work conducted in collaboration with Washington State University (USA) revealed that, while Tanzanian households recognise the need for quality vaccines, past experiences with poor vaccines has hindered their investment in this approach. However, households have expressed a willingness to pay for both routine biannual vaccinations, and for local emergency vaccination at the first signs of a nearby outbreak, provided that they have access to vaccines that work [3.5].

Unlike FMD, effective vaccines are available for the prevention of **anthrax** in livestock. UofG epidemiological and ecological analyses, combined with interactive mapping with communities in at-risk locations, have identified areas and periods of the year associated with an elevated risk of anthrax infection. This research pinpointed both the environmental and climatic characteristics that make areas prone to the persistence of livestock disease [3.6]. Risk factors included alkaline soils with high calcium content, and extremes in weather, with more regular and persistent cases of anthrax occurring during the dry season [3.6]. This research also clarified practices that increase risks to people (such as processing and consuming infected animals) and to livestock (such as being moved to contaminated areas for pasture and water) [3.4, 3.6].

3. References to the research

1. Casey-Bryars M, **Reeve R**, *et al.* [...] **Haydon DT**, Marsh TL, **Cleaveland S**, **Lembo T** (2018) Waves of endemic foot-and-mouth disease in eastern Africa suggest feasibility of proactive vaccination approaches. *Nat Ecol Evol.* 2(9):1449–1457 (doi:[10.1038/s41559-018-0636-x](https://doi.org/10.1038/s41559-018-0636-x)).
2. **Lembo T**, **Hampson K**, *et al.* [...] **Cleaveland S** (2011) Serologic surveillance of anthrax in the Serengeti Ecosystem, Tanzania, 1996–2009. *Emerg Infect Dis.* 17(3), 387–394 (doi:[10.3201/eid1703.101290](https://doi.org/10.3201/eid1703.101290)).
3. Aminu O, **Lembo T**, Zadoks RN, **Biek R**, *et al.* [...] **Forde T** (2020) Practical and effective diagnosis of animal anthrax in endemic low-resource settings. *PLoS Negl Trop Dis.* 14:e0008655 (doi:[10.1371/journal.pntd.0008655](https://doi.org/10.1371/journal.pntd.0008655)).
4. Research report: Anthrax situation in the Ngorongoro and recommended management strategy (2019) [official report to Tanzanian authorities, see also 5.C, PDF available]
5. Railey AF, **Lembo T**, Palmer GH, Shirima GM, Marsh TL (2018). Spatial and temporal risk as drivers for adoption of foot and mouth disease vaccination. *Vaccine* 36 (33), 5077–5083 (doi:[10.1016/j.vaccine.2018.06.069](https://doi.org/10.1016/j.vaccine.2018.06.069))
6. **Hampson K**, **Lembo T**, *et al.* [...] **Cleaveland S** (2011) Predictability of anthrax infection in the Serengeti, Tanzania. *J Appl Ecol.* 48(6), 1333–1344 (doi:[10.1111/j.1365-2664.2011.02030.x](https://doi.org/10.1111/j.1365-2664.2011.02030.x))

Grants:

- Towards the strategic control of endemic foot and mouth disease in Africa: new techniques for a neglected problem, **BBSRC**, 2010–14, GBP892,423 (PI: **Cleaveland**)
- Improving quality of FMDV vaccine and vaccine strains selection in Eastern Africa, **BBSRC**, 2011–15, GBP872,620 (PI: Satya Parida, Pirbright; UofG co-PIs: **Haydon** and **Reeve**)
- Improving capacity for foot-and-mouth disease surveillance and prevention in Africa through direct community engagement, **Merck/MSD Animal Health**, 2015-21, GBP73,408 (PI: **Lembo**)

- Understanding cultural, social and epidemiological drivers of human anthrax infection in rural African communities, **Academy of Medical Sciences**, 2017–19, GBP99,890 (PI: **Lembo**)
- Program for Enhancing the Health and Productivity of Livestock, **Bill & Melinda Gates Foundation**, 2015–18, GBP333,951 (PI: **Haydon**, co-I **Lembo** and **Cleaveland**)
- Molecular epidemiology of *Bacillus anthracis*: novel data and techniques for local surveillance in Tanzania, **EU Commission**, 2015-17, GBP123,269 (PI: **Biek**; fellowship to **Forde**)
- Novel molecular approaches for understanding the epidemiology of endemic anthrax, **BBSRC**, 2018-21, GBP372,842, with a GBP100,000 UofG internal fellowship (PI: **Forde**)
- Transboundary collaborations to enhance surveillance and control of major livestock diseases, **The Royal Society**, 2018-21, GBP224,375 (PI: **Lembo**)

4. Details of the impact

Tanzania has the third largest livestock population in Africa (~30 million cattle), with up to 70% of households dependent on income generated from livestock and agriculture. Livestock diseases contribute to keeping households in poverty, by causing human illness; increasing costs for livestock owners; and reducing livestock productivity. UofG researchers have adopted a grassroots approach to research on FMD and anthrax in Tanzania over many years. They have collaborated with communities and institutions at local and national levels, to determine the most relevant and effective ways to monitor, prevent and treat these diseases. Their approach of multi-level engagement has alerted policymakers to the community burden of livestock diseases, thereby driving disease control and vaccine policies in Tanzania.

Surveillance and control of livestock diseases at the community and regional levels

UofG research has focused on the health problems of under-served communities in rural Tanzania. As a result, these communities are now equipped with tools to demonstrate the impact of livestock disease, and are better able to monitor and respond to disease. Since August 2013, UofG researchers have provided training in **anthrax** surveillance and case management to 60 community-based health workers (representing ~66% and 33% of the animal-health and human-health workforce, respectively) in areas of the Ngorongoro District that are at high risk of anthrax. This district has a population of 180,000 people and 1.8 million livestock, distributed across the UNESCO World Heritage Ngorongoro Conservation Area (NCA) and the Loliondo Game Controlled Area.

UofG researchers have also helped to develop protocols and validate diagnostics for anthrax testing of animal carcasses at the Kilimanjaro Clinical Research Institute [3.3]. These tests confirm the epidemiological links between animal and, indirectly, human cases (based on positive tests from animal samples) given that sampling of severely affected people is extremely difficult. Detection of anthrax has increased since implementation of testing in 2017, in turn prompting follow-up and the provision of free antibiotic treatment to affected people, preventing death in the most severe cases [A, C].

Case reporting was sporadic within the NCA before these diagnostic protocols were made available in 2018 [3.2–3.4]. For example, during 2015–2017, a mean average of 50 cases were reported annually at the principal hospital within the NCA (Endulen Hospital). In 2018, a total of 276 cases were recorded within the wider Ngorongoro District, with 6.5% mortality (18 deaths); in 2019, there were 299 cases, with 4.7% mortality (14 deaths). The Chief Medical Officer at Endulen Hospital, said, “*The activities of the anthrax project have led to enhanced awareness of the disease amongst clinicians...[and] we have benefited from improvements in case detection as a result of the work the anthrax field team are doing on the ground with community members*” [A]. Within the community, the anthrax project has raised awareness of the need to report cases and seek treatment for affected individuals. Speaking to treatment provided at the household level by clinical officers as part of the project, the Chief Medical Officer indicated that it has “*enabled provision of antibiotics to patients who might not have otherwise been able to receive treatment due to their remoteness, and likely prevented the progression of anthrax cases, possibly even preventing deaths*” [A].

Communication networks enabled by UofG researchers, including the anthrax WhatsApp working group, allow households to report suspected **anthrax** and **FMD** cases to UofG-trained health workers, who liaise with UofG teams and health authorities for follow-up. These networks also disseminate important information, such as infection sources and how to reduce disease spread. A Community Animal Health Worker said, *“The WhatsApp working group and the multiple workshops led by Glasgow researchers have widened the network of stakeholders, enabling connectivity between us in the community and those with decision making power all the way from the local leaders to the NCA authority, district-level authorities and even the Director of Veterinary Services. Through the WhatsApp group we are able to access and share data and information from all corners of the world, wherever the members happen to be”* [B]. Improved, community-led surveillance has also resulted in increased numbers of animal disease cases being reported. Prior to 2016, local veterinary records reflected only 5–10 unconfirmed cases of animal anthrax per year [3.2, 3.4]; between April 2016 and October 2018, 491 anthrax-suspected livestock carcasses were tested. Of these, 75% were confirmed positive by molecular methods, indicating that communities accurately recognise anthrax [C]. These communities often have little choice to avoid grazing their cattle in such areas, highlighting the value of livestock vaccination as a strategy to prevent and control anthrax in Ngorongoro District.

National policy for surveillance and control of livestock diseases

The findings of UofG research have also heightened recognition among national officials and policymakers of the impact of livestock diseases on affected communities.

UofG research on **FMD** [3.1] has underpinned policy briefings for the Tanzanian Ministry of Livestock and Fisheries, and also Ministry workshops (in Oct 2013 and 2015), through which findings were shared; for example, the role of wildlife in FMD transmission and offering recommendations on vaccination programmes. In addition, UofG research provided key evidence to facilitate Tanzania joining the United Nations Food and Agriculture Organisation’s (FAO) ‘Progressive Control Pathway for FMD’ (PCP-FMD)—a globally-accepted framework for countries tackling this disease [D, E]. Before the UofG research, Tanzania lacked key data necessary to join Stage One of this pathway (identifying risk and control options). The Tanzanian Chief Veterinary Officer said, *“The [UofG] team has provided us with essential baseline socio-economic and epidemiological data to enter the PCP-FMD pathway and start developing country-specific disease management policies, including our own national FMD control plan in line with PCP-FMD”* [E]. The ultimate goal of progression to the final stages of the PCP-FMD pathway would allow Tanzania to acquire official FMD-free status and trade cattle internationally. UofG research showing limited wildlife-to-cattle transmission risk in Tanzania also revealed that separating livestock and wildlife was unnecessary and ineffective in preventing FMD [3.1]. This work shaped the 2015 Tanzania Livestock Modernization Initiative, on whose steering committee **Prof. Cleaveland** sat, which set out the government’s commitment to improving the livestock industry. This initiative noted that Tanzania would not adopt veterinary fences to contain grazing land (as has been done in other African countries), thus avoiding the environmental and economic costs of such approaches [F].

UofG research and engagement on **anthrax** also led the Tanzanian government to identify this disease as a ‘priority’ zoonosis. In 2017, in recognition of her research expertise in this area, the FAO country office in Tanzania requested support from **Dr Tiziana Lembo** for the development of anthrax control plans with the Tanzanian One Health Coordination Unit. During August 2017–January 2018, Dr Lembo provided evidence-based input into the resulting ‘National Strategy for the Prevention and Control of Anthrax in Humans and Animals 2018–2023’ [G]. The Tanzanian Chief Veterinary Officer highlighted the contribution, pointing out that the document *‘greatly benefited from the input of the anthrax research project led by the University of Glasgow and colleagues in northern Tanzania’* [H].

In December 2018, district-level authorities from the Ngorongoro District, engaged by the UofG anthrax project, initiated discussions with relevant Tanzanian Ministries about implementing and financing livestock vaccination programmes against **anthrax**. To provide a framework for this initiative, Drs **Lembo** and **Forde** worked closely with the NCA District Veterinary and Medical

Officers on a situation analysis; they also developed recommendations for surveillance and prevention measures that would be strategic, locally specific and economical [C]. This strategy was submitted to the NCA Authority in January 2020. In April 2020, the NCA Authority agreed to provide TSH270 million (approx. GBP88,000) to the District Veterinary Office, which used the budget to operationalise and implement anthrax campaigns to vaccinate 273,000 small ruminants during July–August 2020; this targeted ‘at-risk’ areas and species identified by the UofG research [I]. The Tanzanian Chief Veterinary Officer said, “*The approach of the anthrax team has brought the voice of the communities to the attention of local- and national-level authorities, which is to be congratulated given that this is a well-known gap that often compromises our ability to act in response to the needs of affected communities*” [H].

Towards developing a vaccination strategy for FMD

UofG research has showed that monovalent vaccines containing existing **FMD** virus strains can prevent outbreaks caused by the four serotypes circulating in Tanzania [3.1]. Since March 2015, MSD Animal Health has provided GBP73,408 in funding to support collaborative research with **Lembo** and **Reeve** to strengthen FMD surveillance and prevention in Tanzania at the community level (see section 3) [3.1]. The Associate Director at MSD said, “*We were interested in establishing a presence in Africa and contributing to FMD control in the most affected communities...UofG research has provided data and community-level expertise to inform our future strategy development at MSD Animal Health with regards to FMD in Africa—building capacity for surveillance, which has provided a level of strain-level surveillance that doesn’t exist elsewhere in Africa. Furthermore, the learnings from such research are being factored into how we can help in rolling out effective vaccination programs in the region...Through the partnerships the University of Glasgow have in Tanzania we have been able to contribute to a dialogue with relevant national authorities to define what the entry point to this market might be*” [J].

The Tanzanian Chief Veterinary Officer said, “*We recognize that major hurdles to FMD vaccination still exist, particularly in relation to the availability of high-quality polyvalent vaccines that would be efficacious against the multiple virus serotypes and strains we have in Tanzania. Work by the University of Glasgow with industrial partners showing that some of the existing vaccine strains are protective against the four serotypes circulating in Tanzania offers great promise in this area. We look forward to working with colleagues at Glasgow to improve policies and strategies for FMD vaccine sourcing, importation and delivery, and to trial high-potency vaccine formulations on the ground*” [E].

5. Sources to corroborate the impact (PDF of all documents listed are uploaded)

- A. Testimony from the District Medical Officer, NCA.
- B. Summary drawn from qualitative responses collected by Dr Lembo—prepared from notes provided by the Community Animal Health Worker and translated by a native speaker fluent in both Kiswahili and English.
- C. NCA anthrax report: Anthrax situation in the Ngorongoro and recommended management strategy (December, 2019).
- D. [Government and communities in Tanzania benefit from foot-and-mouth disease research](#), BBSRC impact report, February 2016 (PDF, p.3, right column, para 2).
- E. Testimony from Director of Veterinary Services / Chief Veterinary Officer, Tanzania Ministry of Livestock and Fisheries.
- F. [Tanzania Livestock Modernisation Initiative](#), Tanzanian Ministry of Livestock and Fisheries, July 2015, p.31.
- G. National anthrax strategy: (1) National Strategy for the Prevention and Control of Anthrax in Humans and Animals 2018–2023; (2) Email from UN FAO confirming Dr Lembo/UofG role.
- H. Testimony from Director of Veterinary Services / Chief Veterinary Officer, Tanzania Ministry of Livestock and Fisheries.
- I. NCA anthrax strategy: (1) Testimony from the Conservation Commissioner, NCA Authority, Tanzania; (2) Testimony from the District Veterinary Officer, NCA.
- J. Testimony from Associate Director, MSD Animal Health.