

Combining social and natural sciences to understand zoonoses in Tanzania's meat supply chain

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Tanzania is a hotspot for zoonotic enteric pathogens, including *Campylobacter* and non-typhoid *Salmonella* (NTS) which have been described as the 'forgotten zoonoses' of Africa. As the African population grows and urbanises, meat supply chains grow in complexity and size. These changes may offer economic opportunities but they may also present new hazards for public health. Changes in the meat value chain may favour transmission of zoonotic enteric pathogens as meat from a large number of origins is funnelled through a limited number of butchers and eateries to reach a growing number of consumers. Conversely, the changes may also carry the opportunities for improved or more controlled food handling or processing.

To understand risks and opportunities, a multi-disciplinary research team from multiple universities, research institutes and the Tanzanian Ministry of Livestock and Fisheries is investigating cattle and goat slaughtering, butchering, meat handling and poultry farming practices in northern Tanzania using a One Health approach – the Hazards Associated with Zoonotic enteric pathogens in Emerging Livestock meat pathways (HAZEL) project.

Faeces, carcass swabs, and meat from cattle and goats were obtained at slaughter and from butcher premises and cultured for NTS. Cloacal swabs were obtained from live chickens on farms and cultured for NTS and *Campylobacter*. Environmental samples were taken from slaughter, butcher, and farm sites. Interviews were conducted at 20 slaughter locations, 30 butchers' shops, and 30 eateries in Moshi Urban District and Moshi Rural District. Informed by both microbiological and social science, a probabilistic model for the spread of NTS in the beef supply chain in the Moshi Urban District is being developed.

NTS were recovered from 21 (2.7%) of 785 chicken cloacal samples and 13 (16.5%) of 80 chicken farm environmental samples, 12 (2.1%) of 568 cattle and goat faecal samples, 11 (2.4%) of 269 cattle and goat carcass swabs, 70 (10.5%) of 667 beef and goat meat samples, and 31 (13.7%) of 226 environmental samples from slaughter and butcher facilities. *Campylobacter* were recovered from 46 (7.0%) of 657 chicken cloacal samples. NTS were recovered at a significantly higher frequency from cattle and goat meat and environmental samples than from cattle and goat carcass or faecal samples ($p < 0.05$). *Campylobacter* were more commonly isolated from chicken samples than NTS.

Most butchery and eatery workers reported never experiencing a 'major'

meat safety issue related to their own businesses, but had heard of them elsewhere. They had been asked if they had ever, in all the years that they had been working, experienced any major events or problems with meat safety. The definition of what might comprise a 'major event' was deliberately left open to interpretation in order to assess how butchers and meat eateries themselves understood this. Most, but especially rural, interviewees expressed an optimism about the future of meat safety, although this optimism was qualified in many instances. Butchery and eatery workers purchased meat supplies sufficient for a single day's sales, but reported occasionally selling two-day-old meat to consumers, while meat older than 2 days was used as dog food.

Interim findings from the probabilistic model indicates that faecal prevalence for NTS is about 5% for animals entering the food chain whereas approximately 22% of retail meat is contaminated with NTS. Meat from an animal slaughtered at a slaughter slab is three times as likely to be contaminated as meat from an animal slaughtered at the abattoir.

Further isolate characterisation by WGS will be performed to help determine if livestock isolates are contributing to human NTS and *Campylobacter* disease in East Africa. Meat contaminated before it reaches eateries may be made safer for eatery consumers as a result of the eatery practice of boiling meat for long periods. This and other mitigating practices – such as purchasing only enough meat for one day, and not selling old meat for human consumption – reflect local knowledge about food-borne illness and the capacity to make best use of the resources at hand.

Thus, alongside microbiological testing, epidemiological modelling and WGS, social science provides a crucial window into the challenges and opportunities for food safety in Tanzania's rapidly modernizing food supply chain.