Red meat safety from livestock to retail in Tanzania: Policy and practice

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Abstract

Background

Food safety will likely be a major policy agenda item as populations and demand for meat grow and livestock intensification progresses in Tanzania and other low- and middle-income countries (LMICs). Meeting this demand comes with considerable meat safety challenges, risks, and opportunities. This paper offers evidence-based reflections on the governance of the Tanzanian red meat value chain, articulating potential policy implications for red meat food safety in Tanzania and other LMICs.

Methods

This paper synthesizes existing knowledge and data about the food safety dimensions of the Tanzanian red meat value chain, analyzing it through a strengths-weaknesses-opportunities-threats (SWOT) framework. This knowledge and data includes: 1) a review of relevant Tanzanian policy and legislation up to 2020; and 2) published and unpublished multi-disciplinary field and laboratory work conducted under the Hazards Associated with Zoonotic enteric pathogens in Emerging Livestock meat pathways (HAZEL) project in Northern Tanzania.

Results

Strengths include some enabling policies, legislation, workforce, informal networks and infrastructure supporting meat safety. Weaknesses included confusion over mandates, limited resources and infrastructure for compliance/enforcement, lack of data on meat-borne disease, and limited attention to invisible pathogenic meat contamination. Opportunities include strong in-country training infrastructures and the significant economic potential of boosting meat production systems. Although increased revenue could support meat safety investments, this couples with risks of food safety infrastructure failing to keep up with growth (while envisioned increased centralised production may introduce new forms of meat safety risk), and potential inequalities in economic opportunities, gains and meat safety investments, especially for rural, small scale and/or female meat chain actors and their communities.

Conclusions

Agricultural intensification and centralized abattoirs may benefit meat safety and spur economic growth but may not alone generate value for Tanzania and has risks. Investments may overlook rural livestock systems and small-scale actors needing critical meat safety improvements. In addition to basic infrastructure investments, context-appropriate innovations encouraging local-level meat safety may provide cost-effective opportunities for Tanzania and other LMICs to strengthen food safety.

1. Introduction

Low- and middle-income countries (LMICs) bear a disproportionate burden of foodborne disease (FBD). In some countries, including in sub-Saharan Africa, a high proportion of FBD is associated with animal-source foods (Jaffee et al., 2019; Kirk et al., 2015). This can relate to foodborne pathogens such as non-typhoidal Salmonella (NTS) and Campylobacter spp., with contributions of small ruminants, poultry, pigs, or cattle differing between countries (Thomas et al., 2020; Rukambile et al., 2019). At the same time, meat and other animal-source foods are important for both nutritional (Chirande et al., 2015; Kejo et al., 2018) and sociocultural (Århem, 1989) reasons, including child growth, cognitive development, and educational attainment (Neumann et al., 2003; Sanchez, 2020). Governments play critical roles ensuring the safety of animal-source foods through food safety policies at national and local levels (FAO & WTO, 2017; Mwamakamba et al., 2012).

In Tanzania, food safety along the meat value chain is guided by national policies which form the basis for food safety acts (legislation), regulations, strategies, and guidelines at national, subnational, and local levels. This paper presents a synthesis of these policies, laws, and regulations, with a focus on microbiological aspects of meat safety, and contextualised by findings from social science (Hynick et al., 2019; Prinsen et al., 2020; Waldman et al., 2020), microbiological (Crump et al., 2020), and modelling (Zadoks et al., 2021) elements of our Hazards Associated with Zoonotic enteric pathogens in Emerging Livestock meat pathways project (HAZEL). More specifically, we take a strengths-weaknesses-opportunities-threats – or SWOT – approach, with the aim of contributing to ongoing development of Tanzania's livestock and meat safety policy, and to inform broader understandings about meat safety policy in similarly resource-constrained LMIC contexts. The SWOT approach has been previously used to explore operational and policy environments around health and food-related issues to determine and promote future strategic and policy directions (Häring et al., 2009; Saulais et al., 2019; Syazwan Ab Talib & Bakar Abdul Hamid, 2014), including in Tanzania (URT, 2017).

1.1 Background

Recently there has been renewed attention on the importance of food safety in relation to global health threats and sustainability through a One Health framework that recognises the interconnections between human societies, animals (including livestock), and the environment (Garcia et al., 2020). The
Food safety systems in LMICs have been a focus of international agencies with health, agricultural, or animal health mandates such as the World Bank (Jaffee et al., 2019), the World Health Organisation (WHO), the Food and Agriculture Organisation of the United Nations (FAO) (FAO & WHO, 2013), and the World Organisation for Animal Health (WOAH formerly OIE) (Hathaway, 2013). Each have published food safety recommendations, emphasising the importance of food safety control systems, and outlining their approaches to providing country support (FAO, 2007; FAO & WTO, 2017; Mwamakamba et al., 2012; Poissonnier & Teissier, 2013; Slorach, 2013). In addition to reducing domestic FBD burdens, food safety control systems are important for international trade and access to global markets. Economic impacts in the form of trade limitations are associated with inadequate food safety frameworks, infrastructure, and capacity as they can mean systems fall short of international standards for food safety (Jaffee et al., 2019).

Tanzania has the third largest population of cattle in Africa after Ethiopia and Sudan, estimated at 34.5 million head with a growth rate of 2.8% per annum (Kibona & Yuejie, 2021). Eighty-five percent of livestock producers live in rural areas and 62% of rural households keep livestock (United Republic of Tanzania & Ministry of Agriculture and Fisheries, 2015). Almost all red meat produced and consumed in Tanzania comes from pastoral and agro-pastoral communities (Michael et al., 2018). Production systems are often small-scale and low-input. For example, in the Meatu district of Simiyu region between Arusha and Mwanza, average herd size is 53, of which fewer than 10% are sold on average per year. Farmers have limited access to financial credit or veterinary services (Kibona & Yuejie, 2021). Meat is often sold “warm” (i.e., recently butchered, not refrigerated). This is socially and culturally rooted in Tanzania, and suited to economic and infrastructural conditions, such as limited access to refrigeration (Hrynick et al., 2019; Wilson, 2015). The growth of human populations and their wealth, however, drives a rising demand for meat in Tanzania, as well as national policies geared toward intensification of livestock production, meat processing and marketing (United Republic of Tanzania & Ministry of Agriculture and Fisheries, 2015).

Tanzania’s population, currently about 54 million people, is projected to reach 87 million by 2035 (Tanzania National Bureau of Statistics, 2018). The National Livestock Modernisation Initiative of 2015 stated “Wide availability of unhygienic milk and meat across the nation is worrying” (United Republic of Tanzania & Ministry of Agriculture and Fisheries, 2015). Thus, anticipated increases in human population, urbanisation, and consumer demand may further overwhelm the food safety system.

Meat safety concerns begin with livestock management at farm level because meat-borne infectious agents, including NTS and Campylobacter spp., may be introduced into the meat chain by live animals carrying pathogens, predominantly in their gastrointestinal tract. Not necessarily detected through visual inspection at slaughter, they can lead to contamination of meat with foodborne pathogens (Swai & Schoonman, 2012; Thoms, 2000; Waldman et al., 2020). Conditions of livestock transport, markets, slaughter facilities, and butcheries, and product handler behaviour are also important for meat safety (Zadoks et al., 2021). The scope of this paper extends from live cattle through to slaughter premises and butcher shops with a focus on their contribution to the microbiological safety of final products. We refer to this progression from livestock production through raw meat sales as the “meat value chain”. We do not cover the consumption stage of the chain or chemical hazards, such as antimicrobial residues.

2. Methods

This paper synthesises a body of field and laboratory work conducted under the HAZEL project with a bespoke policy review, which together inform our SWOT analysis.

2.1 Field and Laboratory Research

Field and laboratory work took place between 2015 and 2020 in Moshi Municipal Council (urban), Moshi District Council (rural) and Arusha city in northern Tanzania, with support from laboratories elsewhere as needed. It comprised social science approaches to meat safety (Hrynick et al., 2019; Prinsen et al., 2020; Waldman et al., 2020); microbiological studies of live animals, slaughter facilities, and meat (Crump et al., 2020; Sindiyo et al., 2018); and modelling approaches to identify factors affecting the prevalence of NTS in the meat value chain (Zadoks et al., 2021). We also consider previously largely unpublished information collected through systematic observations at slaughter slabs - small sites that usually process one to a few animals per day (Zadoks et al., 2021). These often consist of a cement slab with corner posts supporting a roof. Some slabs are co-located with butcheries where meat is sold (Fig. 1).

Figure 1 Left: slaughter slab with simple structure. Right: butchery with tiled wall and meat hanging inside. Photo: Linda Waldman (left), Gerard Prinsen (right)

Alternatively, carcasses or carcass portions are transported from slaughter slabs, slaughterhouses, or abattoirs by foot, handcart, bicycle, motorcycle or unrefrigerated or refrigerated vehicles to butcheries, where they are divided for retail (Fig. 2).

Figure 2 Meat being transported by handcart. Photo: Mary Ryan

Slaughter slabs (n = 22, including 9 previously described in Waldman et al., 2020) and butcheries (n = 32; described in Prinsen et al., 2020) were visited to interview workers, including slaughter slab operators, meat inspectors, and butchers, with a focus on their perceptions and practices around meat safety. These visits occurred in Moshi District Council and Moshi Municipal Council in northern Tanzania from March through November 2016. Details about the sites and interviewers' methods have been described (Prinsen et al., 2020; Waldman et al., 2020). During interviews, observations were collected by the interviewer or trained assistant using a checklist (checklist available in Additional File 1) including on, for example, the presence of running water or
animals (e.g., dogs, cats, poultry, wild birds) (Fig. 3). Because observer(s) were at each site briefly, observations reflect only the time of day of the visit. Most slaughter activities take place before daybreak.

Figure 3 Outward view from slaughter slab with dogs waiting for scraps. Photo: Mary Ryan

To visualise observational data collected from butcheries, multiple correspondence analysis (MCA) (Greenacre & Blasius, 2006) was performed (data available in Additional File 2). MCA uncovers associations between multiple categorical variables and the categories within variables. It is a "model-free" approach without underlying assumptions about the distribution of data. This makes it versatile for all types of categorical data, especially nominally scaled data (Sourial et al., 2010). Prior to MCA, we removed variables containing categories with very low frequencies (two or fewer observations) to avoid distortion. Post analysis, the choice of variables to display to optimise presentation was determined by the squared cosine, which measures the degree of association between variable categories and a particular axis (Kassambara, 2017). MCA analyses were conducted in R Studio (version 1.4.1106) using libraries FactoMineR (Lê et al., 2008) and factoextra (Kassambara, 2017).

2.2 Desktop inventory of relevant policies, acts, and regulations

We inventoried food safety policies, laws, regulations, and strategies in Tanzania, including national-level policy documents, legislative acts, and regulations. District and municipal-level by-laws were also included in the search conducted by a team of social scientists and veterinarians, including policy makers from the Tanzanian Ministry of Livestock and Fisheries (MLF) (at times also known as the Ministry of Agriculture, Livestock and Fisheries). To make collection of documents as comprehensive as possible, we sought them in several ways including through direct requests to representatives of the Tanzania Meat Board; MLF; Directorate of Veterinary Services (DVS); Tanzania Veterinary Laboratory Agency, Arusha; the Zoosanitary Inspection Unit, Arusha; Zonal Veterinary Investigation Centre; and the Arusha Chamber of Commerce. Searches for relevant references and documents were also conducted on PubMed and Google using combinations of the terms: ‘Tanzania,’ ‘Ministry of [Agriculture,] Livestock and Fisheries,’ ‘meat safety,’ ‘meat hygiene,’ ‘policy,’ ‘slaughter,’ ‘slaughterhouse,’ ‘slaughter slab,’ ‘food safety,’ ‘livestock,’ ‘zoonotic,’ ‘veterinary,’ ‘regulation,’ ‘regulatory,’ ‘livestock officer,’ ‘abattoir,’ ‘meat inspector,’ ‘local government,’ and ‘by-laws.’ Only documents dated after 1990 were considered. Searches were initiated in 2016 and updated each year through March 2021. Only documents published in English were considered, including laws, regulations, and by-laws.

2.3 SWOT analysis

Van Wijngaarden and colleagues (2012) list the following steps as fundamental to SWOT analysis: (1) formulate external developments as opportunities or threats; (2) formulate internal means and capabilities as strengths or weaknesses; (3) confront strengths and weaknesses with opportunities and threats; and (4) use the results to formulate strategic options. The data, publications, and other information sources for our SWOT analysis, as obtained from field and laboratory work and the desktop inventory described above, were synthesised, and identified as belonging to either "internal means and capabilities" (strengths and weaknesses) or "external developments" (opportunities and threats).

2.4 Ethics approval

All work under the HAZEL project was approved by the Tanzanian National Institute of Medical Research (NIMR) (NIMR/HQ/R.8a/Vol. IX/2028, NIMR/HQ/R.8cNol. 11/1069), Kilimanjaro Christian Medical Centre Research Ethics Committee (Certificate No. 832), Ethics Committee of the College of Medical, Veterinary and Life Sciences, University of Glasgow (200140183, 200140152) and Human Research Ethics Committee, University of Otago (H15/069). Permission to publish this work was granted by the DVS and by NIMR.

3. Results

3.1 Field and Laboratory Data

Published findings from HAZEL work included that cooked meat vendors were highly aware of their role in meat safety, whereas butchery and slaughter workers tended to defer to official inspections (Prinsen et al., 2020; Waldman et al., 2020). To be effective, government meat inspectors and other frontline actors involved in meat safety often employed ‘street-level diplomacy’ to balance regulation enforcement with pragmatism and trust (Hrynick et al., 2019). Food safety regulations and inspections tended to emphasise visible abnormalities caused by certain pathogens, often viruses or parasites, rather than potential carriage of bacteria by healthy or healthy-looking animals which may contaminate carcasses during dressing (Waldman et al., 2020). HAZEL work also showed the red meat chain may be a source of human infection with NTS, with live animals and, more importantly, the meat processing environment, contributing to infection risk (Crump et al., 2020; Zadoks et al., 2021).

Results of observations at 32 butcheries and 22 slaughter slabs indicated that a minority of both types of premises had running water for cleaning (3/32 butcheries and 4/22 slaughter slabs) or hand washing (1/32 butcheries and 4/22 slaughter slabs; Fig. 1). Butcheries, which open from ca. 8 or 9 am, usually until they sell all their meat, generally had adequate lighting (29/32). Occasionally, butchers sold unsold meat the following day as dog food at bargain prices. At slaughter slabs, staff were observed wearing uniforms (white coats) at only three out of 22 sites. Animals were frequently observed in both types of premises (28/32 butcheries and 17/22 slaughter slabs). While dogs were most common (Fig. 3), cats, poultry and wild birds were also observed.
The number of slaughter premises included in observations was too small for meaningful MCA, so MCA was only conducted for butcheries. For butchery observations, low frequency categories removed prior to MCA included activities never observed (‘washing hands between handling different pieces of meat,’ ‘washing knife between cutting different pieces of meat,’ and ‘fly control’) and those observed once (‘drying hands on a towel’ and ‘seeing rodents’). In our MCA, the first two dimensions (easiest to visualise and representing the largest proportion of explained variation) covered 36.6% of the total variation contained in the data (22.7% and 13.9% for dimensions 1 and 2, respectively). Variables contributing most to the first dimension were ‘was the meat outside in the sun?’ and ‘was there running water for the building or counter?’ while the variable ‘did the customer seek the official stamp?’ contributed most to the second dimension (Fig. 4).

Figure 4Carcasses that pass inspection are stamped. Photo: Mary Ryan

3.2 Desktop inventory of relevant policies, acts, and regulations

To provide context for specific policies, acts and regulations, a brief overview of Tanzania’s administrative system as relevant to food safety is presented, followed by a summary of key animal and human health policies, and finally details of acts and regulations specifically pertaining to meat safety.

3.2.1 Country administrative and food safety system

At time of writing, the United Republic of Tanzania comprised 31 Regions, including 26 on the mainland and five in Zanzibar (three on Unguja and two on Pemba). These Regions were further subdivided into 134 Districts and 185 Councils. Districts are further divided into divisions, wards, villages, and sub-villages (URT, 2015).

A range of policy and legal actors were responsible for various dimensions of safety. Regional government administration represented by the President’s Office, Regional Administration and Local Government (PO-RLAG) was responsible for the public workforce at regional, district and community levels. This included Livestock Field Officers (LFOs, also called Livestock Extension Officers) including if and when they acted as Meat Inspectors (MIs), and Health Officers (HOs) operating at village, ward, divisional and district levels to implement policies and guidelines issued by ministries (Waldman et al., 2020). The MLF and Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC, split into the Ministry of Health and the Ministry of Community Development and Gender in January 2022), and their Agencies provided policy and technical guidance for food safety. Thus, the public workforce, including MIs and HOs, were administratively responsible to PO-RLAG, but technically responsible to respective ministries. For MIs, this was the DVS in the MLF, while for HOs, this was the Department of Prevention Services in the MoHCDGEC. In general, MIs focused on meat inspection while HOs dealt with cleanliness and hygiene, although in practice their activities often overlapped (Hrynick et al., 2019; Waldman et al., 2020). LFOs worked at ward and village level and provided livestock extension and health services, and sometimes also functioned as MIs. LFOs, and sometimes HOs, also reported to administrative supervisors at village, ward, division, and district executive officer levels, and to technical supervisors including Ward Livestock Officers, District Veterinary Officers, and/or District Livestock and Fisheries Officers. The District Executive Director oversaw both administrative and technical sides at town, municipal, city council, or district levels (Tanzania, 2016).

3.2.2 Animal and human health policies

Policies examined for relevance to meat safety included the Agricultural and Livestock Policy 1997, the National Livestock Policy 2006, the National Health Policy 2007, the Tanzanian Livestock Modernization Initiative 2015, and the revised National Health Policy 2017. The Agricultural and Livestock Policy 1997, focused on trade, did not mention meat or food safety or zoonoses. The National Livestock Policy 2006 described a vision of a modern, commercialised livestock industry by 2025, and support for veterinary services compliant with WTO animal health standards and World Trade Organisation (WTO) sanitary agreements. A stated objective was to improve delivery of animal health services. It also aimed to strengthen zoosanitary infrastructure and inspectorate services to improve quality of zoosanitary inspection, i.e., inspection of health and hygiene status of animals or animal products to prevent introduction and spread of diseases through their movement. The policy provided legal infrastructure for monitoring, regulating and enforcing meat safety standards in Tanzania. This included monitoring and control of zoonotic diseases, some of which may be foodborne. These regulatory, intensification and modernization goals are reinforced and further developed in the Tanzania Livestock Modernization Initiative which aims to ‘improve the quality and performance of Tanzanian livestock populations’ (2015: 14). It states that ‘the government may best transform the traditional livestock sector to a modern one by focusing its efforts to enact a regulatory framework that facilitates rapid private investment’ (2015: 33).

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The National Health Policy 2017 encompassed a broad range of public health concerns, including health services delivery, disease prevention and control, environmental health, traditional and alternative medicine, diagnostics, and consideration of gender and age issues. This policy articulated visions for a healthy population as part of the overall goals of the Tanzania Development Vision 2025. Food safety was mentioned under an Intersectoral Collaboration objective “Sustainable water safety, sanitation, hygiene and food safety.” To enhance food safety, instruments of legislation such as acts and regulations were used.

3.2.3 Acts and regulations relating to meat safety.

In general, national-level legislative acts provided legal platforms for ministries to function and fulfil intentions of national food safety policy. Each act was accompanied by regulations, usually drawn up by relevant ministries, providing more specific guidelines and requirements. Thus, meat safety was governed by an array of acts and regulations (see also Additional File 3).

The Tanzania Food, Drugs and Cosmetics Act of 2003 established the Tanzania Food and Drugs Authority (TFDA), granting it power to make regulations for food hygiene. In 2019, the TFDA was renamed the Tanzania Medicines and Medical Devices Authority (TMDA) and limited to regulation of medicines, medical devices, and diagnostics. The Finance Act of 2019 delegated regulation of food, including food safety, to the Tanzania Bureau of Standards (TBS). At time of writing, the TBS was responsible for regulating activities along the meat value chain including hygiene conditions of premises and health of workers at slaughter, meat processing, transport, storage, and sales facilities, with HOs being key on-the-ground implementers.

Live animal health as related to meat safety was regulated by the Animal Diseases Act No. 17 of 2003 (ADA), overseen by the DVS. Slaughter facilities were registered under the ADA. The Veterinary Act, No. 16 of 2003 established standards and requirements for the veterinary profession around food safety related competencies like zoonotic disease detection and control, and appropriate antimicrobial use. The ADA addressed prevention and control of infectious animal disease by calling for disease surveillance and laboratory capacity for disease detection. The regulations associated with the ADA, the Animal Diseases Regulations 2007, provided the most detailed stipulations for slaughter and inspection by MIs such as how to proceed with animal slaughter and carcass inspection (e.g., where organ cuts should be made, which lymph nodes examined, etc.). Where MIs were not available, an HO could conduct carcass inspections (Hrynick et al., 2019). The Animal Diseases Regulations 2007 specified that knives used for bleeding animals or opening incision lines on a hide or skin are required to be clean and sterilised, and that adequate facilities for sterilisation and disinfection of knives, saws, clothes, and other equipment must be available. After passing inspection, a carcass was considered a food item, and transportation from slaughter, and the conditions of storage and sale of meat then became the responsibility of the TBS.

The Environment Health Practitioners (Registration) Act of 2007 and Public Health Act of 2009 established standards and requirements for HOs, Environmental Health Practitioners and other ‘authorised officers’ around food safety related competencies and ethics. The Public Health Act of 2009 also provided authority to the Health Minister and the MoHCDGEC to make regulations regarding food safety and specified that district or urban authorities could regulate slaughter facility activities. They stipulated HOs could undertake meat inspections and condemnations, disease reporting, and had authority to seize condemned food, and/or close facilities. The Public Health Act empowered HOs to ensure hygienic conditions of slaughter facilities, butcheries, and food shops. Thus, there was overlap between TBS, DVS and MoHCDGEC jurisdictions, although the TBS primarily covered the general hygiene infrastructures of food production premises, food transport and health of workers, whereas the DVS covered animal disease and threats to human health directly related to animal disease through pre- and post-mortem examination of animals, etc. All three agencies have authority to remove and dispose of unsafe meat. Various other Acts covered issues with relevance to the meat chain. For example, the Animal Welfare Act No 19 of 2008 (with GN No245 of 2010) had implications for likelihood of pathogen presence; the Occupational Health and Safety Act covered workplace equipment and hygiene; and the Environmental Management Act covered waste disposal (detailed in Additional File 3).

National-level acts were complemented by local, decentralised regulations. For example, local meat safety regulations for Arusha were published by the Municipal Council as local by-laws in 1998 (Council, 1998). These reinforced principal acts and provided additional context-specific requirements around issues such as use of clean aprons and insect screens, and exclusion of dogs. They also required all animals slaughtered within the city to be slaughtered at the Council’s abattoir and that meat be transported in clean receptacles.

3.3 SWOT analysis

Based on our analysis of policy documents, observations during site visits, and other HAZEL project results, SWOT analysis was conducted. Strengths and weaknesses internal to the system were identified in the legal and administrative domain, and in food safety infrastructure and implementation of official policy (Table 1 – see Additional File 4). Opportunities and threats external to the system included elements of the national economy, and issues specific to food safety and human health (Table 2 – see Additional File 5). Aspects of knowledge and training were deemed relevant in both realms.

3.3.1 Strengths and weaknesses

Whilst several policies empowered government entities to support meat safety activities, they made only brief or tangential mention of food safety and may not have fully reflected ground conditions. Local-level regulatory infrastructure was in place, and food safety actors were legally empowered to implement it, but the separation of administrative and technical oversight, combined with the overlapping responsibilities between TBS, DVS and MoHCDGEC may have created confusion among meat safety actors. The set of relevant policies identified and reviewed represent almost “too much of a good thing.” Infrastructure to support the meat value chain, such as markets and slaughter facilities existed, but compliance or inspection of compliance
with legislation in such locations was not always possible due to infrastructural and logistic constraints. Lack of data on the public health burden caused by meat-borne disease may have contributed to those constraints through a typical “neglected tropical zoonoses” cycle whereby, lack of infrastructure and enforcement leads to lack of data, and thus no evidence and weak impetus to improve infrastructure or enforcement of food safety regulation, perpetuating the lack of data availability. Informal communication networks provided opportunities for knowledge sharing and training among street-level policy enforcers and slaughter workers, but officials’ knowledge was not necessarily complete, leading to implementation gaps (Hrynick et al., 2019). In particular, there was limited awareness or concern of foodborne pathogens originating from faecal contamination as opposed to visibly abnormal carcasses. Further details and examples for internal strengths and weaknesses are listed in Table 1, in Additional File 4.

3.3.2 Opportunities and Threats

The most opportunities and threats for meat safety were identified in the domain of the national economy. There is enormous economic potential considering the size of Tanzania's cattle industry, but there is also risk that food safety infrastructure will not keep up with meat production. A focus on increased production and international markets could pose a threat to domestic markets. Alternatively, economic growth of the meat value chain could provide resources to support local food safety infrastructure and strengthen the domestic market. At government level, there has been considerable interest in animal disease and food safety, and extensive collaboration at supranational level, both regionally and globally. Limitations in diagnostic capacity, however, may result in failure to trigger implementation of guidelines available through such collaborations. Likewise, there are excellent in-country training institutions, which could provide training on animal health and food safety at various levels, possibly bridging from international entities like FAO or WOAH to street-level actors like LFOs and MIs. Even so, the number of experts and availability of funds may not be sufficient to implement this at scale. Finally, meat safety policy is gender-blind, lacking recognition the different health risks and opportunities that may be faced by or available to women and men due to the different roles they may play in meat value chains. Further details and examples of external opportunities and threats are listed in Table 2, found in Additional File 5.

4. Discussion

Tanzania has policy, legislative, and legal infrastructure to address challenges regarding meat safety along the meat value chain. Responsibility for implementation of meat safety laws falls with several entities, including the TBS and agencies within the MLF, and at the time of study, the MoHCDGEC (now MoH). Enforcers, however, were not necessarily administratively answerable to the Ministries and there can be competing demands on their time and resources, including means of transportation. In view of this, there could be potential conflicts of interest among actors. Harmonisation of some legislation and a more integrated regulatory framework could be expected to improve efficiency. The transfer of the TFDA mandate to TBS was intended to alleviate some of this conflict, but this transfer has not yet led to a change in responsibilities regarding food safety. In addition to facing administrative and inspectorate challenges, the country is still under-equipped and -resourced in terms of infrastructure and human resource development to implement all Codex Alimentarius meat hygiene recommendations. Existing and future staff require training (including on-going training) and investments in equipment (e.g., motorbikes) to do their work efficiently.

Tanzania currently has a limited number of modern abattoirs which primarily serve cities (Grace et al., 2019). A more centralised production system with additional abattoirs may have both risks and benefits. In high income countries where food is processed and distributed at large scales through centralised systems, foodborne outbreaks can be widely distributed and have large impacts (Dewey-Mattia et al., 2018; Jones & Yackley, 2018). At the same time, centralisation and addition of new abattoirs may further enable a supply of safe meat to rapidly urbanising populations in Tanzania, as this may support implementation of system-wide food safety measures that can prevent foodborne outbreaks (Kotisalo et al., 2015), while also providing opportunities to enter meat export markets. However, both the National Livestock Policy 2006 and the Tanzanian Livestock Modernization Initiative 2015 are weak in promoting trade-facilitating infrastructure and services which could support commercial development, especially in rural areas where poor feeder roads, limited livestock haulage and holding facilities limit the potential of livestock and meat value chains. Furthermore, it may be especially beneficial to direct resources and investment to rural areas to support meat safety and public health, and rural animal-based livelihoods upon which many millions of Tanzanians rely (Bundala et al., 2020; Schwab & Armah, 2019). For example, investments in rural infrastructure and services such as roads, sanitation, clean and safe water, electrification, training, and other resources could directly and indirectly help make slaughter slab operations safer and enhance other parts of the meat value chain through which most Tanzanians obtain meat. A combination of centralised and decentralised investment, directly and indirectly related to meat value chains, has potential to improve well-being of both urban and rural Tanzanians not only in terms of food safety and food and nutrition security through animal-based foods, but also through social and economic benefits. Revenue generated from export could be used to support local infrastructure that could further directly improve meat safety, while also supporting social and economic development more broadly.

Hygienic practices during slaughtering, handling, and marketing of meat are recognised worldwide to be critical for reducing microbial contamination of raw meat. The zoonoses most frequently detected during visual meat inspection in Tanzania are cysticercosis, hydatidosis (Fig. 6), and bovine tuberculosis (Komba et al., 2012; Swai & Schoonman, 2012).

Figure 6: Inspection of organs for visible abnormalities, such as this cyst in a bovine liver. Photo: Mary Ryan

In interviews conducted as part of the HAZEL project, easily recognisable anthrax was also commonly mentioned, with MIs having high confidence in their ability to detect it (Waldman et al., 2020). Meat inspection at slaughter should also detect visible faecal contamination, which can be a source of foodborne pathogens such as NTS (Crump et al., 2020). Contamination from less obvious sources, such as slaughter environments (including non-visible
faecal contamination), also plays an important role in driving Salmonella prevalence in meat (Zadoks et al., 2021). This suggests the need to invest more in mitigating this type of contamination. Our survey revealed very few slaughter facilities had full-time running water for cleaning sites or hands. Slaughtering animals and selling meat in open places lacking clean water and other infrastructure likely increases risk of raw meat contamination. This contamination may originate from the slaughtered animals or the people killing, dressing, butchering or inspecting them (often with bare hands) (Fig. 6), and through transport of meat, or direct or indirect contact with other animals (dogs, birds, insects; Figs. 3 and 7) (Zadoks et al., 2021).

Figure 7 Inspected and approved liver with flies. Photo: Mary Ryan

Fortunately, due to continuous efforts of government and non-governmental development partners, there has been progress in the practice of slaughtering and meat handling. We observed many butchers for instance, who installed floor and wall tiles (Fig. 1), wore white protective coats, used covered meat transportation vans, and installed running water where possible (although we occasionally observed non-working basins; see Fig. 8).

Figure 8A basin without running water being used for storage in a butcher shop. Photo: Gerard Prinsen

Theoretically, support for in-service training in Hazard Analysis/Critical Control Points (HACCP) principles would be helpful for staff at slaughter points (Tompkin, 1990). Interview findings by HAZEL investigators also suggested butchers and meat sellers operating in conditions challenging for meat safety are open to collaboration and adaptation (Hrynick et al., 2019; Waldman et al., 2020). In practice however, there are several barriers to implementation and impact of such training, including: a shortage of MIs or others to deliver it; competing priorities for use of government-owned resources such as motorcycles; insufficient access to some slaughter points, especially during adverse weather; lack of infrastructure including for running water and electricity. Thus, in addition to formal integration of HAACP principles within the meat value chain when and where possible, policy makers could also support meat safety through other means including supporting slaughter workers more skilled in minimising cross-contamination (such as from hides and inadvertent intestinal punctures) to provide peer training to others, including new workers. Investments in alternative energy like solar power, could provide heat and light to support meat safety activities including freezing, cooling and sterilisation of environment and equipment (such as through use of steam for sterilisation). Existing and planned water, sanitation and hygiene programmes could be expanded to include livestock slaughter settings, enabling workers to mitigate contamination more easily.

Tanzania’s many cattle, sheep, and goats represent a valuable resource and opportunity for development of a more productive and efficient system that could increase national income and mitigate poverty (United Republic of Tanzania & Ministry of Agriculture and Fisheries, 2015). Livestock policies have been heavily focused on opportunities for marketing and export, which requires disease control and food safety assurances (Michael et al., 2018). Thus, as shown above, current visions for developing the meat value chain and improving meat safety as articulated in the, National Livestock Policy and the Tanzania Livestock Modernization Initiative, focus primarily on intensification and mechanisation to increase production scale and reach export markets. These possibilities are however likely to only be available to already large-scale, more urban-connected actors. They do not necessarily consider social and developmental aspects of the livestock sector and internal markets and may overlook the livelihoods and roles of small-scale actors in meat production and meat safety, particularly in rural areas. This includes women as livestock producers (and in agriculture more broadly) as their roles are currently under recognised and under-supported in relation to financial, training and extension support (Isaya et al., 2018) and there are opportunities to invest in their more equitable participation (UN Women, 2015). Indeed, the value (and potential value) of the livestock sector extends far beyond macro-economic considerations. Animal-based livelihoods are vital for many rural and small-scale value chain actors and their communities. Livestock production and meat safety policies which overlook these aspects may inadvertently encourage unsafe slaughter practices and pose threats to rural economies, human health and animal-based livelihoods. By contrast, national policies and initiatives could emphasise the potential for improved meat value chains which include rural systems, and more centrally emphasise aspects of food security, nutrition, and socio-cultural value in future policy strategies.

5. Conclusion

Food safety will likely be a major policy agenda item as populations and consumer demand for meat grow and livestock intensification progresses in LMICs. In Tanzania, policy and legislation reflect the need to ensure these needs are met (although some of it would benefit from streamlining). However, financial, technical, and infrastructural constraints represent major barriers to development of further physical infrastructure and reaching the numbers of public Ethics ameat-safety personnel required, along with their training, transportation, and communication. Furthermore, HAZEL research (Hrynick et al., 2019; Prinsen et al., 2020; Waldman et al., 2020) and information from other sources (Grace et al., 2019; B. A. Jones et al., 2013) suggest agricultural intensification and commercialisation combined with more centralised abattoirs, while potentially providing meat safety and economic growth benefits, may not alone be sufficient to generate value for Tanzania, and may also come with risks. Most critically, while such investments may support meat safety and economic opportunities (e.g., export), rural livestock systems and communities may be overlooked for critical investment that could improve meat safety in these settings. In such settings, basic infrastructural investments, alongside context-appropriate local-level innovations may represent cost-effective opportunities for improving meat safety. Further, leveraging existing skills and improving infrastructure like roads, accessible, clean and safe water, and electrification will not only help improve meat safety and food security and support related livelihoods, but contribute to well-being on a wide range of social, cultural and economic fronts.

Declarations

Availability of Data and Materials
The observational data discussed in this paper is available in Additional File 3. This paper also draws upon data already presented in other papers published on HAZEL research, availability of which is detailed in those publications.

**Ethics Approval**

All work under the HAZEL project was approved by the Tanzanian National Institute of Medical Research (NIMR) (NIMR/HQ/R.8a/Vol. IX/2028, NIMR/HQ/R.8c/No. 11/1069), Kilimanjaro Christian Medical Centre Research Ethics Committee (Certificate No. 832), Ethics Committee of the College of Medical, Veterinary and Life Sciences, University of Glasgow (200140183, 200140152) and Human Research Ethics Committee, University of Otago (H15/069).

**Consent to Publish**

Permission to publish this work was granted by the DVS and by NIMR. This work does not contain data from any individual person.

**Competing Interests**

The authors declare that they have no competing interests.

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**Author contributions**

TH, MAD, LW and RNZ contributed to interpreting the data, writing the original draft and to reviewing and editing. ES, JB, SC, JAC, NPF, EK, RK, BM, BTM, NM, GP, JP and KMT contributed to the interpretation of the data, reviewing and editing the manuscript. JB contributed to the multiple-correspondence analysis and visualisation. BM contributed to acquisition of the original observational data presented in this manuscript. MAD, TH, LW, ES, and NM contributed to identifying and gathering the policies and legislation reviewed in this manuscript. SC, JAC, BTM, GP, KMT, LW and RNZ contributed to design of the project and supervision of the research.

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**References**

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**Figures**

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Left: slaughter slab with simple structure. Right: butchery with tiled wall and meat hanging inside. Photo: Linda Waldman (left), Gerard Prinsen (right)
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Meat being transported by handcart. Photo: Mary Ryan

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Carcasses that pass inspection are stamped. Photo: Mary Ryan

Figure 5
Multiple correspondence analysis plot summarising observations made at 32 butcher shops in Moshi, northern Tanzania, with variables and their categories coloured by their contribution to the variance. Categories clustered about the centre of the plot are considered average for the data set.
Figure 6

Inspection of organs for visible abnormalities, such as this cyst in a bovine liver. Photo: Mary Ryan

Figure 7

Inspected and approved liver with flies. Photo: Mary Ryan
Figure 8
A basin without running water being used for storage in a butcher shop. Photo: Gerard Prinsen

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