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Benefits of Using a Transdisciplinary Approach for the Design and Operationalization of a Surveillance System

This case illustrates the benefits of using a transdisciplinary approach when designing and operationalizing a surveillance system. Through stakeholder engagement, an electronic meat inspection form was developed and used in Western Kenya, and the electronically captured data could be used to develop a slaughterhouse-based syndromic surveillance system.

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Abstract

During the preparatory phase of a surveillance project in Western Kenya, it was noted that several animal health activities, including meat inspection, were recorded using paper-based forms. Through discussions with the meat inspectors and other slaughterhouse actors, an electronic meat inspection form was developed, tested, and used in two slaughterhouses in Bungoma County. The meat inspectors completed and submitted a form for every animal slaughtered at their facility over a 2.75-year period. In a feedback meeting with the meat inspectors and other stakeholders, areas for improvement were highlighted, such as the timely provision of feedback to the data providers, and the inclusion of data fields that allow for more detailed animal movement information. The meat inspectors remarked that the form made them feel appreciated and added value to their work as the data could be used to educate farmers on prevailing livestock conditions and provide economic incentives for disease control interventions. The data submitted via the electronic forms were of sufficient quality to be summarized and identify trends in the animal slaughterhouse throughput, as well as frequent reasons for meat condemnation and associated costs. These data could therefore set the foundation for a syndromic surveillance system based on slaughterhouse data. Other non-traditional data sources, such as livestock and meat transport certificates, could also be leveraged to create a post-farm animal health information system.

What is the Incremental Value that Makes this a One Health Case?

One Health recognizes that the health of humans, animals, and the environment depends on each other. The health of human communities is connected to animals and the environment through the food they consume, while those who work directly with animals, such as farmers and slaughterhouse workers, are more likely to be infected by zoonotic diseases. Animal diseases also lead to wastage in terms of reduced productivity and meat condemnations, with consequent economic and environmental implications.

One Health also advocates for the use of a transdisciplinary approach, whereby all those affected by a specific problem are included in discussions on how to address it. Such a participatory and integrative approach helps create linkages between sectors and disciplines, generating new knowledge and improving the acceptability and sustainability of proffered solutions.

One Health themes that added value to this case study included:

1) A transdisciplinary process and stakeholder engagement were used to develop data collection forms.
2) These forms allowed us to turn observations currently recorded on paper into data that are useful for surveillance and decision-making about disease risks in meat.
3) These data can be used:
   a. To inform farmers about the food safety and zoonotic risk to themselves and the people they provide food to.
   b. To provide evidence on the costs of condemnations and guide interventions, including education programmes for farmers on methods of disease control aimed at reducing the economic losses.
   c. For an indicator-based surveillance system to identify changing disease risks.
   d. For developing policy to reduce food pathogens and zoonotic disease risks.

Learning Outcomes

1. Learn about the importance of transdisciplinary/participatory One Health approaches for the development of sustainable surveillance systems.
2. Understand the importance of engaging the data collectors/providers in the design of the data collection tool and the information created.
3. Understand the advantages and value of leveraging cheap and readily available IT tools to provide benefits in low-resource settings.

Background and Context

Surveillance

Surveillance is defined as 'the continued watchfulness over the distribution and trends of incidence through the systematic collection, consolidation and evaluation of morbidity and mortality reports and other relevant data' (Langmuir, 1963). Surveillance activities are intimately linked with disease control as they provide population information which can then guide the planning, implementation, and assessment of disease control measures. Surveillance is also important for monitoring trends and patterns in disease distribution, and it can provide early warning signals about emerging or re-emerging pathogens.

Surveillance systems vary depending on the scope, population, and pathogen of interest. Traditionally, surveillance has been based on the collection and analysis of samples to confirm the presence or absence of the pathogen of interest. While such activities remain an integral part of surveillance systems, they can be complemented by surveillance based on non-traditional data sources. Such surveillance activities are referred to as syndromic surveillance or indicator-based as they monitor indicators of change that may be associated with an increased disease or disease risk in a population (EFSA, 2022). Examples of indicators include, but are not limited to, production or mortality records, online searches for specific terms associated with disease, absenteeism records, or drug sales.

Syndromic surveillance has several advantages compared to traditional surveillance methods. It is less resource intensive as it often relies on data that are already being collected for other purposes. Since it is based on early disease indicators, syndromic surveillance can detect changes prior to traditional surveillance and is therefore suited for early warning systems. Moreover, it does not require laboratory diagnoses, making it particularly useful when laboratory resources and infrastructure are limited (Chretien *et al*., 2008; May *et al*., 2009; Paterson and Durrheim, 2013).

Zoonoses in Livestock in Kenya

The Zoonoses in Livestock in Kenya (ZooLinK) project aimed to develop an integrated surveillance system for zoonotic diseases in three counties in Western Kenya, namely Busia, Bungoma, and Kakamega (Falzon *et al*., 2019). For this project, 12 sentinel sites were selected. Each site comprised a livestock market, a neighbouring slaughterhouse, and a hospital nearby. We visited each site once every 4 weeks, over a 2-year period, and at each site we sampled up to 10 animals and/or patients. We then processed and tested the biological samples at the laboratory facilities in Busia (Fig. 1a–d). This allowed us to carry out surveillance in the more traditional sense, by looking for disease and measuring its frequency in our population of interest.

Fig. 1. Sampling of animals in livestock markets (a) and slaughterhouses (b); patient consultations at hospitals (c); processing and testing of biological samples at the field laboratory (d).

While developing the sampling frame and sampling strategy for the ZooLinK study, several field visits and stakeholder meetings were held to better understand the study area and operating systems. Throughout this preparatory stage, we noted how several activities, including meat inspection, were documented using paper-based records which, despite the wealth of information they contain, often end up shelved and forgotten. Hence our idea to develop an electronic meat inspection form so that the observations currently recorded on paper could be converted to electronic data. This would facilitate the monitoring of changing patterns in condemnations which, in turn, could represent changing disease patterns in the community and could eventually become part of an indicator-based surveillance system.

While the results of the pilot study on electronic meat inspection forms have been reported elsewhere (Falzon *et al*., 2021), here we want to provide more details on the contextual background, the study conception and development, and thoughts on how the system could be further developed into an animal health information system. The purpose of this case study is to demonstrate the value of a transdisciplinary approach to design and operationalize a surveillance system that can benefit farmers, meat inspectors, meat consumers, and government policy makers.

Transdisciplinary Process

Understanding the context

In Kenya, meat inspectors are obliged to keep records of the animals slaughtered at their facility (Fig. 2a), and of any eventual condemnations. Condemnations may involve the whole carcass or individual organs. Carcass condemnation occurs when the carcass is emaciated or covered in cysts, if the animal is dead on arrival, or if there is a suspicion of recent treatment with antibiotics. When a carcass is condemned, the meat inspector must write a certificate of condemnation. This certificate is issued in duplicate copies: one copy is retained and the other is given to the owner of the animal (Fig. 2b). On the other hand, if only certain organs are condemned, no certificates are issued but the meat inspector must record these condemnations in his/her notes, including information on the animal, the organs condemned, and the reason for condemnation.

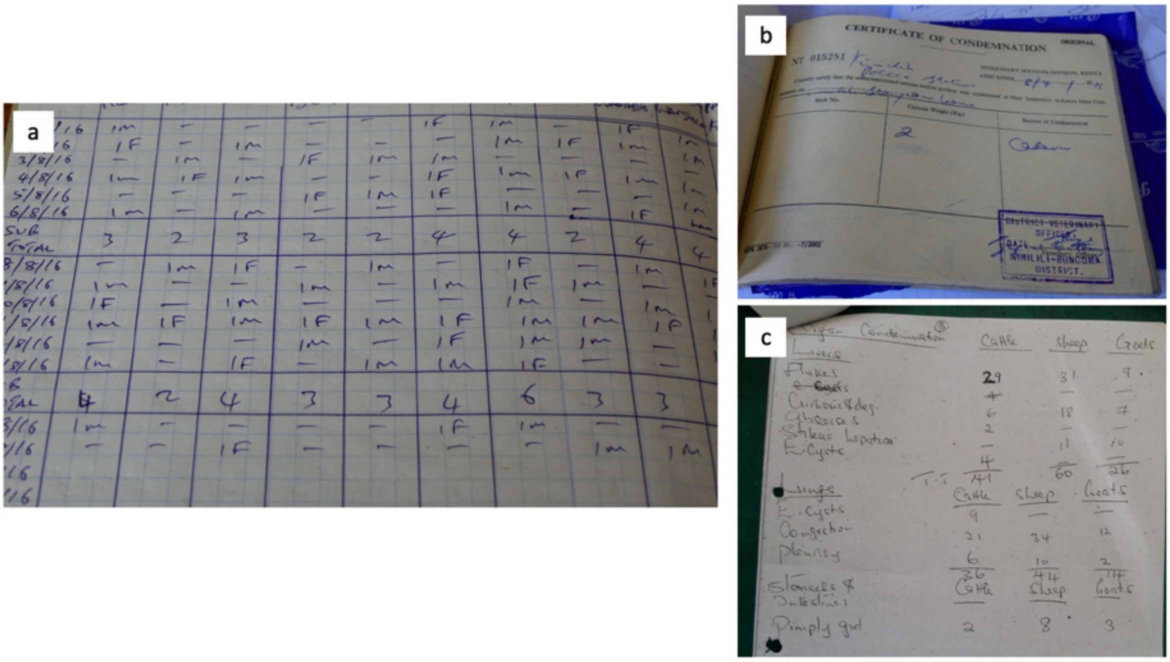

Fig. 2. Records of animals slaughtered on the premise daily (a); certificate issued upon condemnation of the whole carcass (b); and monthly report of organ condemnations (c).

These daily records are then compiled in a monthly report and shared with the county official veterinarian (Fig. 2c). These reports contain a wealth of information on the most frequently encountered animal health issues in the area and how much meat and, consequently money, is being lost due to condemnation. They could therefore inform and provide economic incentives for targeted disease interventions. However, being paper-based, the data are unstructured, making it hard to extract relevant information in a timely manner.

Stakeholder engagement during project design and operationalization

During the ZooLinK preparatory visits, we had the opportunity to observe the meat inspectors during their work. We noted the challenges in keeping track of the paper-based records and the added burden of transcribing daily and monthly reports. Through discussions with the meat inspectors and others involved in the slaughter process, the idea to develop and trial a meat inspection electronic form emerged.

For the project we selected two ruminant slaughterhouses in Bungoma County – one in Kimilili (Fig. 3a) and one in Webuye (Fig. 3b). Both were categorized as Class B medium slaughterhouses based on their throughput and infrastructure and were therefore permitted to supply meat within a 50km radius as per the Meat Control (Local Slaughterhouse) Regulations (CAP 356, 2012). These two slaughterhouses were selected as they had better infrastructure compared to other slaughterhouses in the area, and because of the good relationship we had developed with the meat inspectors. Both slaughterhouses operated 7 days a week, with a daily slaughter of approximately seven cattle and ten small ruminants, and were busiest on their respective market day (Thursdays in Kimilili and Wednesdays in Webuye). The slaughterhouse in Kimilili had 11 permanent staff and one meat inspector, while the slaughterhouse in Webuye had six permanent workers and two meat inspectors.

At each slaughterhouse, we met with the meat inspectors to discuss the design and implementation of the project. They also shared with us the information they routinely collected, and any other parameters they were interested in capturing. They specifically requested the inclusion of condemnation weight and cost parameters as they believed these would provide important evidence about the disease burden in their community.

With this in mind, we developed a standardized, multi-media, electronic form for data collection which was later uploaded on smartphones. The form included questions on (i) the slaughterhouse location and meat inspector completing the form; (ii) the species, age, sex, physiological status, and origin of each slaughtered animal; and (iii) whether there were any condemnations. In case of condemnations, there

Fig. 3. The slaughterhouses in Webuye (a) and Kimilili (b).

were follow-up questions on whether the whole carcass or single organs were condemned, the reason(s) for condemnation, and the estimated weight (in kg) and market value (in Kenyan Shillings [KES]) of the condemned part. The date and time were captured automatically during the completion and submission of the form. Most questions were formulated as single- or multiple-choice questions with drop-down menus to minimize data entry errors, and the form also allowed for the uploading of photos or videos.

We then met again with the meat inspectors to show them how the form could be completed and submitted (Fig. 4). Following a trial and revision period, whereby the meat inspectors were encouraged to submit test forms and identify any challenges with the process, the meat inspectors were asked to complete and submit a form for each animal slaughtered at their facility. The forms and their data were captured in real-time and stored in an electronic database (Fig. 5).

Fig. 4. Testing the forms with the meat inspectors in Webuye (a) and Kimilili (b).

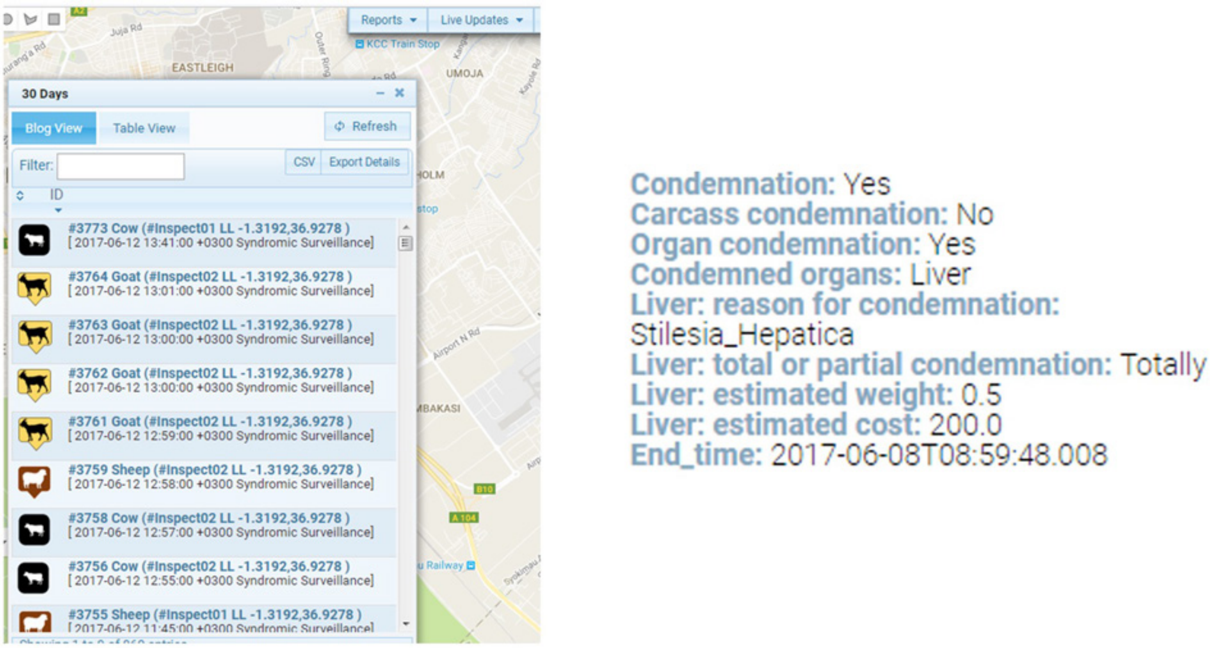

Fig. 5. Electronic forms submitted by the meat inspector available in real-time on the database.

Project Findings

The study ran from March 2017 to December 2019 and during this period 16,383 reports were submitted, approximately 16 reports/day. These included reports for 7182 cows, 3709 goats, and 5495 sheep slaughtered at the two facilities; almost all these animals were over 6 months of age. The overall sex distribution of the animals was roughly equal, with 8114 female and 8247 male animals, and most animals' last stop before being brought to the slaughterhouse was within Bungoma County.

Almost a quarter of the slaughtered animals (n = 3777) had some form of condemnation. Of these, only 38 involved the whole carcass, while the rest involved one or more organs. The proportion of animals with a condemnation was highest in cows (32.6%), compared to sheep (20.1%), and goats (7.4%).

The most frequently condemned organ was the liver (63.4% of all organ condemnations), followed by the lungs (21.6%), and the intestines (5.6%). Livers were primarily condemned due to the presence of liver flukes or hydatid cysts caused by *Echinococcus* spp. parasites. Hydatid cysts were also the leading cause of lung condemnation, followed by pneumonia. Intestines were frequently condemned due to the presence of nodular lesions caused by the parasite *Oesophagostomum* spp., a condition known as 'pimply gut'. These results are comparable to findings from the other surveillance data where both liver flukes and hydatid cysts were common post-mortem findings (Falzon *et al*., 2019), and a parallel study confirmed the presence of *Echinococcus granulosus sensu stricto* in some of the hydatid cysts that were processed and sequenced with PCR (Mutwiri, data not yet published).

For cattle, the median estimated weight of the condemned liver, lungs, and intestines was 3kg, 3kg, and 2 kg, respectively, while the median estimated value of each condemned liver, lung, and intestines was 1200 KES (9.54 USD), 600 KES (4.77 USD), and 600 KES (4.77 USD), respectively. The median weight and market value of sheep and goat organs condemned were similarly estimated.

Project Feedback

In April 2019, a feedback session with the participating meat inspectors and other stakeholders was held. During this workshop, the interim study results, challenges encountered, and the potential way forward were discussed.

The meat inspectors highlighted how the most frequent reasons for condemnation – liver flukes, hydatid cysts, and pimply gut – were all parasitic diseases that could be managed through specific interventions.

For example, liver flukes could be tackled by telling farmers to avoid grazing their animals in swampy areas and explaining how deworming their animals was cost-effective as it would reduce losses due to condemnations. It was also noted that hydatid cysts caused by cystic echinococcosis, a zoonotic disease transmitted between dogs and ruminants and with humans acting as occasional aberrant hosts, could be mitigated through proper fencing of slaughterhouses that would prevent dogs from accessing condemned meat. A study to examine dogs' infection levels with taeniid eggs in the same study area identified *Echinococcus canadensis* and other zoonotic parasites in dog faecal samples, highlighting the importance of regularly deworming dogs (Mutwiri *et al*., 2023).

One of the participating meat inspectors noted that completing the electronic forms was time-consuming, estimating that it took roughly 30 minutes every day to submit all the forms. Other limitations were also highlighted, including the need to provide feedback to the users, the role other stakeholders play (e.g., butchers exerting pressure at the slaughterhouse or animal traders not providing the requested information), and the importance of collecting other sources of data (e.g., the origin of animals at the auction rings). While the form contained a question on the animal's origin, this only captured the animal's last stop and therefore did not capture its complete movement history since many of these animals would often have travelled from much further away. They gave as an example cystic echinococcosis, which is traditionally known to be present in the northern county of Turkana and had previously not been reported in the study area. They thought it likely that animals with hydatid cysts were coming from these areas, but the data collected through the form did not allow them to document this. Liaising with auction officers at the livestock markets to obtain information on the animal's travel history and leveraging data captured through movement permits were proffered as solutions to help map the spread of cystic echinococcosis and other diseases.

Overall, the meat inspectors said the system made them feel their work had value and provided them with an opportunity to learn. They also recognized its usefulness in summarizing the data they painstakingly collect every day so it could be used as evidence to inform disease control strategies that would benefit both the farmers and the meat consumers.

Project Impact

This pilot project showed that the use of electronic meat inspection forms for data collection is feasible even in resource-limited settings. The data collected were of sufficient quality and completeness to provide baseline information on the number and species of animals regularly slaughtered in these facilities. The data also provided insights on the burden of diseases in the livestock population, highlighting both the zoonotic disease risks to farmers and meat consumers and the economic losses that are being incurred due to the condemnations. These insights can be used to engage policy makers and other stakeholders in the development and implementation of disease control strategies and to inform farmers about diseases in their animals and how these can be prevented. The tool has had national interest, and digital training and integration of the use of such a tool into the curriculum of the Kenyan Meat Training Institute might be a good way forward.

Project Outlook

Besides the meat inspection records, other data sources could be tapped into to develop a surveillance system that captures animal health information from when the animal leaves the farm to the butchery.

Farm animals are either bought by butchers who take the animal directly to slaughter or by livestock traders who then re-sell the animals at livestock markets. All animals that are brought to or taken from a livestock market, as well as animals that move across counties or sub-counties, must be accompanied by a movement permit (Fig. 6).

Any meat that leaves the slaughterhouse must be accompanied by a certificate of transport which indicates that the carcass has been inspected and passed fit for human consumption (Fig. 7). This document is issued in duplicate copies: the original copy accompanies the meat and should then be placed next to the meat at the butchery, while a replicate is kept by the meat inspector in case the need to trace the source of meat arises.

Data collected in these forms, if digitized, could be used to determine movement patterns post-farm, from livestock markets to slaughterhouses and on to butcheries (Fig. 8). Understanding these networks could help predict disease spread and improve food traceability.

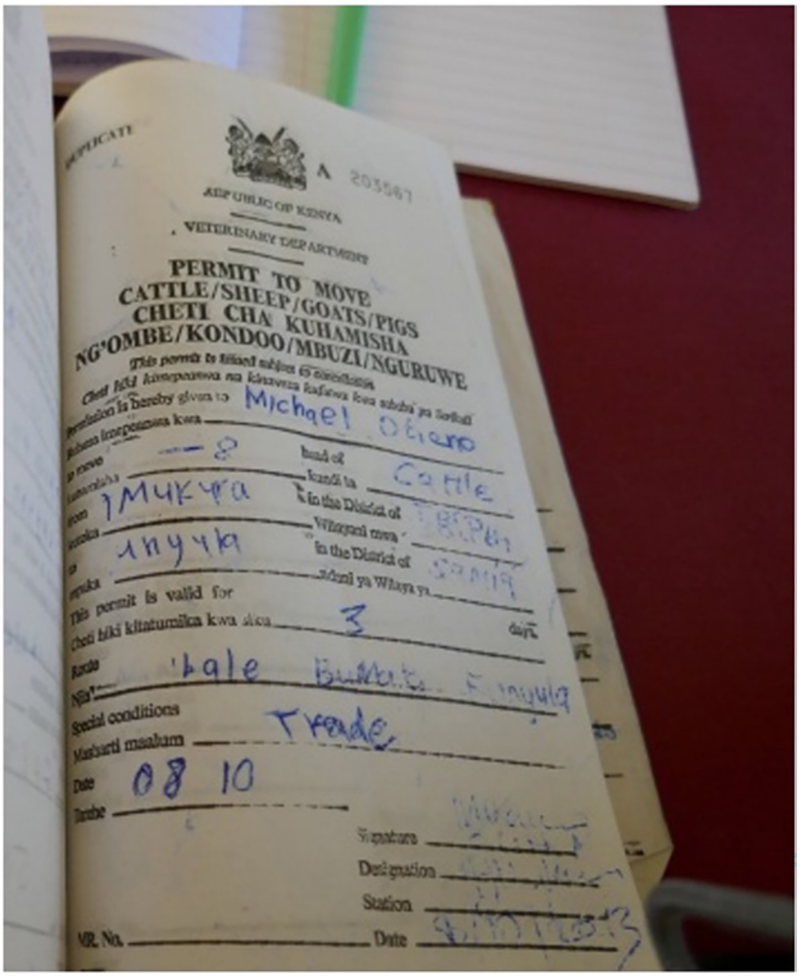

Fig. 6. Duplicate copy of a movement permit issued to a trader who purchased an animal in a livestock market. This document must accompany any animal travelling across counties or sub-counties.

Fig. 7. A copy of the transport certificate issued by the meat inspector, which should accompany the meat and left on show at the butchery (a); the metal crates used to transport the meat to the butcheries (b).

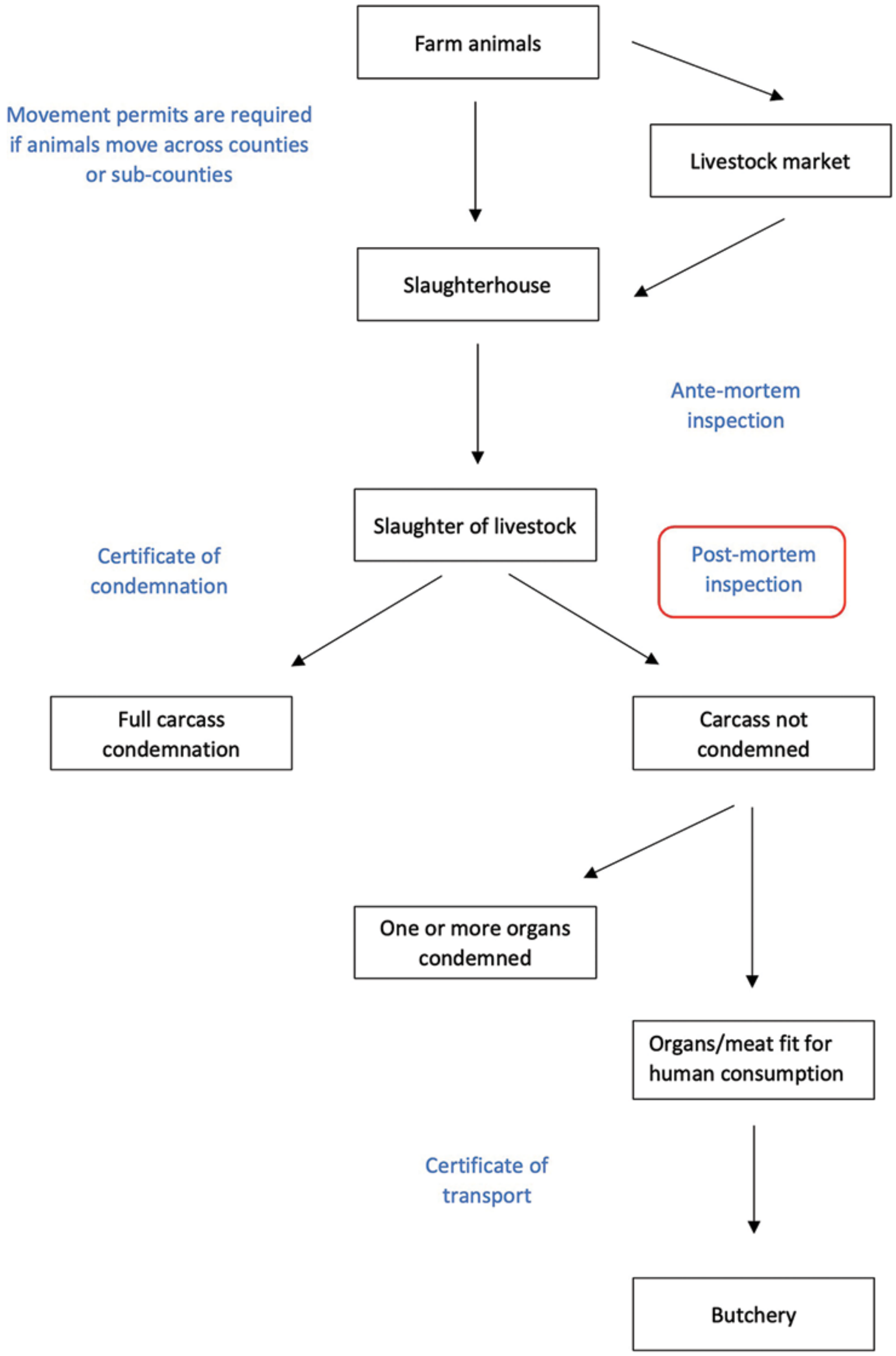

Fig. 8. A flow chart to illustrate the slaughter process and associated reporting. Highlighted in red is the part that this tool captured, while other processes/reporting forms indicated in the blue text could be digitized to contribute towards a post-farm animal health information system.

Conclusions

The participatory approach adopted in this case study was instrumental to the success of this project. Through our ongoing discussions with the meat inspectors, we were able to learn from their direct experience in the field and ensure that the forms and eventual surveillance system met their objectives. The project also made them feel valued, and they took pride in the fact that their role helped safeguard food safety and public health.

The implementation of the electronic form was low-cost and low-tech. Developing the form required only a minimum amount of work and technical expertise, and no IT infrastructure was needed as the data were all cloud-based. These advantages make this type of approach ideal for low- and middle-income countries that have limited resources.

Our experience illustrates that it is possible to develop an indicator-based syndromic surveillance system based on routinely collected slaughterhouse data. While meat inspection data are traditionally collected for food safety purposes, they can also support public health, animal health, and animal welfare interventions, illustrating the added value such a surveillance system would bring.

Group Discussion Questions

1. When do you think a syndromic surveillance system should be considered?
2. Can you think of other stakeholders that could have been included in this case study?
3. Which other non-traditional data sources can be leveraged for surveillance activities?
4. For what other purposes can the data collected at the slaughterhouse be used?

Acknowledgements

Relevant data can be accessed at: https://doi.org/10.17638/datacat.liverpool.ac.uk/1400.

All the photographs included in this case study were taken by the lead author or other members of the ZooLinK field team, and all those who appear in the photographs provided their consent.

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