RESILIENCE IN THE PORK SUPPLY CHAIN FROM THE FOOD SAFETY PERSPECTIVE

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Summary

Challenges in food production are plenty, while resources are scarce. In the interest of the consumer as well as the producer, it is of utmost importance to prevent unwanted events from happening. This may be done through focus on resilience in the pig and pork supply production in relation to food safety. In this paper, resilience - and its counterpart vulnerability - is introduced and discussed specifically for food safety. It is noted that to manage unwanted events, focus must be on effective handling on the event itself. But focus should also be on the patterns of events - including the trends in society which may be leading to increased or decreased risks. To gain a more comprehensive understanding of these patterns, an analysis of the entire structure of the production system is necessary. Through an analysis of these three levels - event, patterns and structure - and their complex interrelationships, targeted prevention activities may be identified and put in place to raise the system’s long-term resilience. Hereby, the risk to consumers and producers can be reduced to an acceptable level. Such risk-mitigating activities may consist of surveillance, own check systems, HACCP, risk analysis, and legislation including use of private standards.

Definition of resilience and vulnerability

Resilience may be defined in different ways depending on the context. In this paper, the definition used in general systems theory is applied: the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks. Moreover, in this paper resilience is not just seen as a response to an acute event but also as the ability of the system to prevent events from happening in the future.

In pig and pork production, resilience may be interpreted as the capacity of the value chain to recover after unwanted events such as zoonotic disease outbreaks in the pig population or feed/food contamination. These events may lead to perturbations of the system and requirements for withdrawal of the product. Subsequent negative effects may be seen on the income of the Food Business Operator (FBO i.e. the farmer, the abattoir, the meat processor, the retailer) due to the necessary handling of the event and loss of consumer confidence which will lead to a lower future market share.

Vulnerability may be interpreted as the contrary of resilience. Vulnerability analysis is a process that defines, identifies, and classifies the weak points and links (vulnerabilities) in a network or production chain. In this process, uncertainty can - and should - be taken into account, so we can prepare for the unexpected. In this way, the value chains will be able to constantly deliver the values demanded by the consumer: plenty of safe and nutritious food at an affordable price.
An increased focus on resilience and vulnerability is also important to secure employment and income - and hereby for the sustainability of the entire value chain.

**Unwanted events require response**

We tend to focus on individual events and not the trends and deeper structures leading to them. For example during an outbreak of Salmonella, the event may be detected through an increase in the number of human cases. This imposes a response by the authorities and the supply chain. Once the source of infection has been identified, targeted actions are taken, such as withdrawal of the product from the market, whereby costs are incurred to the industry. Hence, the whole system of food safety regulations and public and private governance in place are part of resilience, because it allows reacting to these events and make sure that public health and animal health are protected. However, if focus is only on the event itself, resources are spent on responding and future outbreaks may not be prevented appropriately.

**Patterns of events provide understanding**

Contrary to events, which may be interpreted as a here-and-now picture of a single incident, patterns represent a series of events. This implies using surveillance/monitoring data to address location, timing, frequency and size of events and change in these. This includes analysing the causes of the individual events - and by discerning commonalities get an idea of how prevention may be initiated.

In line, change in consumers’ behaviour and purchase patterns should be foreseen and dealt with. An example is the move towards a higher demand for outdoor-produced pork, which changes the risk patterns and puts new requirements on food safety measures/prevention methods in the food supply chain.

Trends outside the value chain may also influence the patterns of events. Climatic changes may result in an expansion of the habitat of an insect or a parasite leading to an increase in the disease burden of the animals that form part of the supply chain. Likewise, demographic changes may imply establishment of urban populations in areas previously free from human activities, which may lead to a higher probability of introduction of pathogens into the food supply chain. This emphasizes that food supply chains are nested in a social-ecological context that is unpredictable from a mere production chain perspective and demands a broader approach.

**Analysis of the structure reveals identification of solutions**

To get a more comprehensive understanding of what is leading to unwanted events, it is important to analyse the structure of the supply chain. Hence, an identification of the vulnerabilities during the chain could help to identify weak points and links. This implies focus on the identification of the factors, which influence the probability of the unwanted event as well as factors impacting on the size of the consequences. Moreover, the capacity to respond when needed should be assessed to understand what to do to solve a specific issue. Finally, the time dimension - including changes in the system over time - is important to elucidate.
Ways of undertaking such analyses include 1) simple sketches of the production including risk pathways, and causal loop diagrams 2) clinical trials and risk factor studies (e.g. for contamination during processing) to bring about information about the size of the individual effects and 3), risk assessment including simulation or modelling as well as economic analysis. Such activities can generate knowledge about what to do in the most cost-effective way. The work should be made in an iterative way, preferably in a group of people with different qualifications, and in collaboration with the relevant actors and stakeholders to get the best-suited overview of the system. Here, it should be remembered that the selection of stakeholders will impact on the scope of the analysis and the understanding of what effectiveness means.

Figure 1. Description of how events, patterns and structure of a supply chain may be interrelated (adapted after Anderson & Johnson, 1997).

An analysis of the value chain with a focus on the vulnerabilities can forecast the effectiveness of proposed countermeasures and evaluate their actual effectiveness after they are put into use. For food safety, such measures include good manufacturing practices (GMP), own check, HACCP, preparedness, and targeted surveillance activities. Other tools may consist of private standards, which are voluntary in principle, but which have to be complied with, if the FBO want to be part of the quality label represented by the private standard.

Example 1: Antimicrobial resistance

Increase in antimicrobial (AM) resistance constitutes an unwanted food safety event. Limitation on the use of AM in pigs may be considered a timely reaction intended to lower the negative long-term effect on resistance development in humans. But without a deeper focus on what is causing the need for treatment, negative side effects may be seen e.g. animal welfare issues related to the lack of treatment of ill animals. Moreover, production may be less effective, if use of AM is limited unnecessarily. Finally, the effect of the action taken (to improve human health) may be lower than expected, because the AM use in humans is maintaining the resistance levels observed in human pathogens and indicators.
Another approach may be to focus on the need for treatment of livestock, which is often related to pig-specific pathogens. This implies that an analysis is undertaken to elucidate which conditions are associated with AM use. Then, focus can be directed towards prevention of these conditions including development of cheap and easy-to-use vaccines, as well as focus on management including age and weight at weaning and type of feed. These interventions may help to maintain herd health even in the presence of pathogens. Moreover, both zoonotic and non-zoonotic pathogens may be kept at bay, if external biosecurity is high. Likewise, spreading of infection within a herd may be kept to a tolerable level, if internal biosecurity is high. In this case, specific use of AM may be allowed as a timely reaction to an acute health issue - and the potential negative impact on human and animal health due to resistance development is kept low due to prudent use of AM.

Example 2: Residues in pork

Residues are unwanted from a consumer point of view and may lead to a requirement for withdrawals on the local market and to export bans on sensitive markets. Residues may consist of AM arising from lack of compliance of withdrawal times after treatment with AM. But residues may also consist of illegal substances such as hormones or of environmental polluters such as dioxin. Actions are warranted to keep the prevalence of residues of AM at a low level - and to keep the other kind of residues away from the supply chain. An apparently effective instrument would be to operate with high fines in case of non-compliance. However, monitoring for residues is expensive as there is a plethora of residues to look for in feed and pork. Therefore, only a limited proportion of the feed batches and carcasses are tested officially leading to low surveillance system sensitivity. A fining system may therefore not be very effective.

Instead an analysis along the supply chain of what may cause presence of residues in pork should be undertaken. This may show that no illegal substances or environmental polluters are found, and that penicillin is the AM most commonly found in monitoring. Moreover, it may be revealed that sows apparently have a higher probability than finishing pigs. Then, interviews with affected farmers may disclose that sows were sent to slaughter before the withdrawal period was over due to a mistake arising from inadequate marking, poor record-keeping and lack of communication. A discussion with producers may reveal that for finishing pigs, it is easy to comply with the withdrawal times, because the date of slaughter is known. Hence, the vulnerable part of the system is the sow production, where time of slaughter is not pre-planned.

As a solution, several actions can be taken: 1) tools to mark treated sows can be developed, 2) a requirement for own check related to farmers’ AM treatment can be put into the private standard governing pig production and 3) regular campaigns may be planned targeted pig producers informing them about the consequences of not complying with withdrawal periods. By use of these initiatives, the system becomes more resilient in the long run as it prevents the event from occurring.
Discussion

It is only natural that we try to simplify systems to get an overview of cause and effect. However, the scientific approach of A leading to B while maybe incorporating the effect of C as a confounder may not correctly reflect the systems we are operating with. Therefore, predictions of effect of risk mitigation may be wrong, wasted and misleading. In the more complex cases, multi-collinearity is often present and should not be ignored as it in fact may reveal the correct relationships to react on. This can be done by using explorative and analytic techniques such as adaptive Bayesian network analysis, factor analysis, advanced causal loop diagrams, and risk assessments. In all cases, uncertainty should be taken into account to help prepare for the unexpected.

Vulnerability and resilience in food safety may not be interpreted the same way all over the world due to different contexts related to diversities in risk perception, production systems, and economic abilities. Still, we may be able to learn from sharing results and experience - enabling identification of other ways of addressing a food safety threat than the one commonly used in an area or country. By the end of the day, this could result in acceptance of equivalence of approaches used in other countries easing trade for the benefit of consumers, producers and society as a whole.

References