# ACMSF Horizon Scanning workshop 2024

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# ACMSF Horizon Scanning Workshop (June) 2024 summary of discussions and outputs

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## ACMSF horizon scanning workshop 2024 summary of discussions and outputs

**Date of Workshop:19th of June 2024**

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# Executive Summary

The ACMSF Committee held a horizon scanning workshop in York on the 19th of June 2024 to help identify and further understand the effects of climate change on UK food safety, in line with the FSA's commitments under the Third National Adaptation Programme (NAP3).

The workshop concluded that the greatest food safety risk during flooding and drought was likely to be from Verotoxigenic and Shigatoxigenic *Escherichia coli* (VTEC/STEC) contaminating crops and RTE fruit and vegetables, while the greatest risk during a heatwave was likely to be from *Listeria* in chilled food due to disruption to the cold chain. Overall, the greatest risk is likely to be of faecal contamination of crops and ready-to-eat (RTE) fruit and vegetables during flooding, drought, and heatwaves.

# Introduction

The Advisory Committee on the Microbiological Safety of Food (ACMSF) held a horizon scanning workshop in York on the 19th of June 2024. The format of the workshop was devised by the secretariat and was intended, among other things, to help identify and further understand the effects of climate change on UK food safety, in line with the FSA's commitments under Risk Action H9.1 of the government's Third National Adaptation Programme (NAP3). All committee members were invited to attend, and collectively represent expertise in microbiology, food safety, public health, epidemiology, veterinary science, and food industry practices.

# Methods

The FSA sought member input on which emerging microbiological issues and food sectors to prioritise, particularly in identifying probable indicators of climate change. Members were asked to score the risk of specific pathogens emerging during flooding, drought, and heatwave:

- *Escherichia coli*
- *Campylobacter*

- *Listeria*
- Norovirus
- *Salmonella*
- *Vibrio*
- Viruses such as Hepatitis A and B
- Verotoxigenic and Shigatoxigenic E.*coli* (VTEC/STEC)

The food sectors considered were:

- Fish
- Shellfish
- Beef
- Poultry
- Eggs
- Dairy (milk and cheese)
- Raw dairy
- Imported eggs
- Crops
- Ready-to-Eat (RTE) fruit and vegetable
- Chilled food sectors

Prior to the workshop, the secretariat sent the questions to committee members to gather responses before discussions took place. The responses can be found in Annex 1.

During the workshop, three discussion groups were created and randomly assigned. Each group was provided with the same information, guidance, and table template (Annex 2). Groups were asked to assign scores from ten (most significant) down to one (least significant) to emerging microbiological issues within specific food groups that could arise following changes to the climate. Members were asked to consider the effects severe weather conditions (flooding, heatwaves, and drought) may have on food production, processing, and supply chain as well as the impact on food consumption and imports. Members were also asked to summarise key causes of the risks and mitigation strategies. Once each group had completed their scoring, a discussion was held to form a consensus. This paper summarises the main consensus and outcomes based on workshop discussions. General thoughts and deliberations have also been captured.

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# Results

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# Results

The design of the workshop produced a meaningful consensus; however, the committee found it challenging to provide scores as a group. Members could not always provide scores 1-10 as certain factors limited the ability to rank (for example, some pathogens were deemed to have the same level of risk for the same food group.

**Q1 - Score the risk of emerging microbiological issues within specific food groups that could arise following severe flooding.**

The participants agreed that VTEC and STEC contamination of crops (specifically leafy greens) and RTE fruit and vegetables were the biggest risk following extreme flooding (scoring 10 and 9, respectively). The participants highlighted that VTEC/ STEC contamination during flooding is likely to affect any field or irrigated crop due to an increased risk of contaminated run off and increased splashing of water onto crop.

*Listeria*, *Salmonella* and Norovirus contamination of RTE fruit and vegetables were scored 8, 7 and 6, respectively, as the most important risk following severe flooding. The key causes for the increased risk were also linked to irrigation problems and splashing. As well as additional sources of contamination, RTE fruit and vegetables do not have to be cooked by consumers (heating to a

temperature sufficient to kill pathogens).

Norovirus in shellfish was also identified as a likely risk during or after flooding. The three groups assigned this risk different scores (8 or below); however, it was agreed that norovirus in shellfish is the next likely risk due to flooding. Therefore, a consensus was drawn that norovirus in shellfish scores 5. The participants agreed that the key cause for norovirus contamination of shellfish is likely to be due to increased pollution caused by sewage spillover and intentional discharge into the sea.

After scoring risks from 10-5, although the participants could identify further pathogen-sector combinations that might increase in risk they felt unable to assign risk rankings to them. The reasons given were that the risks were difficult to quantify, similar and/or contingent on other uncertainties (such as the level of resilience in the national power supply). Therefore, instead of allocating scores below 5, the participants continued the task by simply identifying the food sector and contaminating pathogens that are likely to pose a risk in flooding events. All groups identified viruses (e.g., HepA, HepE) and VTEC/STEC in shellfish due to sewage pollution and discharge into the sea.

One group identified *Salmonella* and VTEC/STEC in beef as potential risks following flooding. This was linked to the movement of wild animals (e.g., rats) which can spread pathogens to livestock. However, the other groups did not identify beef as a food sector that will be affected by emerging microbiological issues caused by flooding.

All groups agreed that *Campylobacter* and *Salmonella* are a risk for poultry during flood events. This risk could be caused by contaminated drinking water and a loss of strict biosecurity measures at the farm level.

VTEC/STEC and *Listeria* contamination of dairy products (including milk and cheeses) and raw milk/ raw milk cheeses were identified by all groups as being a risk following flood events. The impact pathway was less direct in this case but is expected to be caused by the interaction between greater contamination of the outdoor environment interacting with poor hygiene practices and lack of control measures.

*Listeria* was identified as a risk for the chilled foods sector during a flood. This was only identified by one group during separate discussions but during the wider discussion, all groups agreed that this may be an issue due to a breakdown in societal infrastructure e.g., loss of power to keep refrigerators at the correct

temperature.

One group suggested that *Salmonella* in imported eggs may be a risk during flooding. This was linked to reduced domestic supply and reliance on increased import from countries with *Salmonella* prevalence in eggs. However, UK eggs and fish were the only food sectors that the participants did not assign a flood related risk of emerging microbiological issues. Additionally, *E. coli* and *Vibrio* were the only microorganisms not assigned a risk score or identified as emerging microbiological issues during flood events. A table summarising the consensus results can be found in Annex 2.



# Question 2 - Score the risk of emerging microbiological issues within specific food groups that could arise following drought?

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**Q2 – Score the risk of emerging microbiological issues within specific food groups that could arise following drought?**

Like flooding, the ACMSF participants agreed that VTEC/ STEC contamination of crops (specifically leafy greens) as well as RTE fruit and vegetables were the biggest risk caused by drought (scoring 10 and 9 respectively). The participants agreed that drought will lead to marginal water sources, leading to poor hygiene practices on farms due to improper disinfection or recycling of contaminated water.

The participants also agreed that *Listeria* was a risk to crops and RTE fruit and vegetable sectors during drought. During individual group discussions *Listeria* in crops and RTE fruits and vegetables were assigned different scores (8 or below).

However, a consensus was reached during the all-group discussion, and they scored 8 and 7, respectively. The key causes driving the increased risk include poor hygiene practices and increased import levels needed to meet demand if domestic food production was to be negatively affected. The participants agreed that increasing import may put a strain on infrastructure, leading to breakdowns in the cold chain.

After scoring the risks 10-7, the groups had different opinions on which emerging microbiological issues, and the impacted food sector should be assigned the scores 6-1. Moreover, some groups also struggled to assign a score (as previously described) and instead identified food sectors and emerging microbiological issues that may occur during drought.

Groups identified VTEC/STEC, *Salmonella* and *Listeria* in raw milk and raw milk cheeses as being a risk during drought. The key causes were a lack of hygiene practices at all industry levels and the potential of stressed animals becoming more prone to infection.

All groups identified *Campylobacter* and *Salmonella* in poultry as being an increased risk following drought (variable scoring across groups). It was also largely agreed that the beef sector would also be affected by drought as *Salmonella* and VTEC/STEC may cause emerging issues. The participants agreed that drought will lead to stressed animals with increased susceptibility to infection.

The participants agreed that fish, shellfish, UK eggs, imported eggs, dairy (including milk and cheese), and chilled foods were food sectors least likely to be affected by drought and were not highlighted as concerns for emerging

microbiological issues following drought. A table summarising the consensus results can be found in Annex 3.

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# Q3 - Score the risk of emerging microbiological issues within specific food groups that could arise following heatwaves?

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### Q3 - Score the risk of emerging microbiological issues within specific food groups that could arise following heatwaves?

The participants agreed that *Listeria* contamination in chilled food scores 10 as it is the combination that poses the highest risk during a heatwave. The participants agreed that a heatwave may result in the loss or disruption of supply chains, and an inability to keep food chilled. This may lead to increased pathogenic replication.

The participants also agreed that VTEC/STEC in RTE fruit and vegetable and crops scores 9 and 8, respectively. The participants agreed that a reduced water supply during a heatwave may negatively impact hygiene practices. The participants also discussed changes in consumer behaviour during a heatwave: for example, there is an increase in salad consumption during warmer weather, and increased exposure may lead to more illness within the population.

After assigning the scores 10-8, the groups had different opinions on which pathogen-food sector combinations should be assigned the remaining scores. Moreover, some groups also struggled to assign a score (as previously described) and instead identified sectors and emerging microbiological issues that are likely to occur during a drought. As a score consensus could not be reached the following results will describe the sectors and pathogens the participants identified as being a likely risk during a heatwave.

All groups identified *Campylobacter* and *Salmonella* in poultry as being an increased risk during a heatwave. Some groups also identified VTEC/STEC in beef as a risk. The participants agreed that a heatwave has the potential to increase mortality of livestock including poultry, leading to an increased demand for imported meat. The participants suggested that a decrease in flock numbers or increased stress may reduce the production of domestic eggs. This scenario could create an increased need for imported eggs: thus, the risk of *Salmonella* in imported eggs may also increase during a heatwave.

Groups identified *Listeria* and *Vibrio* in fish and shellfish as a risk during a heatwave. The participants agreed that the risk of *Listeria* in fish (e.g., salmon) is likely to increase during a heatwave due to the challenge of maintaining the cold chain. Whereas *Vibrio* is likely to increase in fish and shellfish if seawater temperatures rise.

All groups agreed that *Listeria* will likely affect the dairy (milk and cheese) sector during a heatwave. Some groups also suggested that *Salmonella* and VTEC/STEC will affect the dairy sector during a heatwave. The key causes were linked to a loss or disruption of supply chain, inability to keep food chilled and increased pathogenic replication in processing environments. Therefore, *Listeria*, *Salmonella* and VTEC/STEC in raw milk/ raw milk cheeses will also be a risk during a heatwave.

The participants agreed that UK eggs are the food sector least likely to be affected by a heatwave and was not highlighted as a concern for emerging microbiological issues. Moreover, *E. coli*, Norovirus, and viruses (e.g., HepA and HepE) were not identified as microbes most likely to pose a threat to food sectors

during a heatwave. A table summarising the consensus results can be found in Annex 4.

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# Q4- What mitigation strategies, including any monitoring approaches could be implemented to detect and prevent weather related food risk?

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### Q4-What mitigation strategies, including any monitoring approaches could be implemented to detect and prevent weather related food risk?

Regarding severe weather conditions (flooding, drought, heatwave), the workshop participants identified potential mitigation and monitoring activities. It was suggested that increased viral testing and general surveillance can aid early detection of weather-related outbreaks. It was also suggested that there is an

increased need for parasite and virus surveillance in shellfish.

Expert decision systems and forecasting based on other countries that have experienced severe weather conditions may help guide preventative or responsive protocols. Using the Early Warning System (EWS) and monitoring the stability of the cold chain may also be helpful and a practical approach for mitigation. Monitoring of the cold chain can be extended to food businesses and retailers to ensure adherence to set standards. Increased genomic sequencing for antimicrobial resistance is another important strategy for monitoring how pathogens are adapting. Furthermore, a useful mitigation strategy for FSA to adopt would be a programme to enhance consumer awareness of pathogen growth in relation to higher temperatures, to encourage safe practices (e.g., monitoring refrigerator temperatures during a heatwave).

**Q5- Members were asked to provide ideas to support research projects associated with the IID3 project, specifically low-cost, passive sampling methods for identifying the main causes of foodborne disease. Responses are described below:**

1. Improving detection methods in samples i.e. metagenomics.
2. Partner with health apps to track gastrointestinal symptoms
3. Coupling meteorological data with surveillance data
4. Use of AI to integrate multiple sources of information.
5. Wastewater monitoring, extend to look for markers of different pathogens.
6. Link IID to national lab databases. IID3 specific to GP practices and geographic locations but could link to lab data to give more information.
7. Random retail surveys and link to IID3. Couple the data for source attribution.
8. Monitoring of feed and products for mycotoxins.
9. One health approach for IID3.
10. AMR surveillance including antifungal resistance.
11. Supplement the bowel cancer sampling protocol for additional tests such as genome sequencing.
12. Monitor the sale of anti-diarrhoeal medicine as an indicator of an outbreak.



# Discussion and key conclusions

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# Discussion and key conclusions

The UK climate can impact the risk of pathogenic contamination in the food sector. Extreme weather events such as increased rainfall and flooding, drought, and heatwaves can influence how pathogens spread, grow, and contaminate food sources. Certain food sectors, particularly those dealing with fresh produce (e.g., crops, meat, seafood, dairy produce), are vulnerable to pathogens due to their direct exposure to environmental factors. Therefore, food sectors may need to upgrade or amend their existing control protocols to anticipate increased pathogen risks due to climate change. This discussion will explore the key food categories at risk, the associated pathogens, and the underlying causes contributing to the sector-specific risks during extreme weather conditions (flooding, drought, and heatwaves).

# Flooding

Flooding is defined as an overflow of water that submerges land which is usually dry; caused by heavy rainfall, river and costal overflow, dam breakage or overwhelmed drainage systems (1). Flooding can increase the risk of pathogen contamination in several ways. The participants highlighted that heavy rainfall, and flooding can lead to the contamination of water supplies used for irrigation in agricultural fields. Runoff from nearby livestock farms, where animal manure is

used as fertiliser, can introduce pathogens such as VTEC/STEC, *Salmonella*, and *Campylobacter* into fields of crops, particularly leafy greens. The contaminated water may splash onto crops during irrigation or heavy downpours, spreading pathogens directly onto produce which is a particular concern for fruits and vegetables that can be consumed raw.

During flooding, contamination of rivers and lakes with sewage or animal waste is common. Floodwaters can also spread pathogens such as viruses (HepA, HepE), bacteria (Salmonella, *Listeria*, E.coli) as well as parasites such as Cryptosporidium (not included in the workshop exercise). Therefore, crops may be directly or indirectly contaminated via irrigation or floodwater. Livestock farms (poultry and beef) may also experience wet and muddy conditions during flood events. This can lead to poor animal hygiene, increasing the likelihood of contamination of animal-derived food products. The participants highlighted for example, mud and faecal matter on farms can introduce *Salmonella* and VTEC/STEC into dairy and meat products during the milking or slaughter process. This is particularly problematic in the UK during the rainy seasons when farm conditions are challenging to manage.

The participants also highlighted that shellfish, particularly filter feeders (mussels and oysters), are vulnerable are vulnerable to waterborne contamination in coastal regions after floods due to sewage overflow incidents. This can introduce the emergence of bacteria such as VTEC/STEC and viruses into shellfish supply. This can pose a significant risk to consumers, especially when shellfish is eaten raw or undercooked.

# Drought

Drought is typically defined as an extended period of significant below-average rainfall, leading to a shortage of water (2) Drought conditions can significantly impact the food sector by creating environments that facilitate the emergence and spread of pathogens. While drought may seem like a situation where moisture-related pathogens might be less of a concern, the indirect effects of drought can increase the risk of contamination in several ways. The participants highlighted that droughts create a limited access to clean, fresh water for agricultural purposes. This may lead to an increased reliance on untreated or recycled water for irrigation and farming. Untreated or recycled water may carry a higher pathogen load, including bacteria such as VTEC/STEC, *Salmonella* and *Listeria* which can contaminate crops or the soil in which they grow.

Moreover, the participants discussed how livestock health may be affected during a period of reduced availability of clean water and feed. Firstly, a lack of water can create unsanitary conditions due to inadequate disinfection processes, promoting the growth and spread of pathogens. This may increase the likelihood of contamination during milking or slaughter. The participants suggested that bacteria such VTEC/STEC, *Salmonella* and *Listeria* have the potential to emerge as a risk for livestock and dairy products due to the potential for contamination. This is of particular concern for raw milk and raw milk cheeses as these have more limited control measures to eliminate pathogens that may be present. Furthermore, during drought livestock may experience stress and malnutrition, leading to stress. Stressed and undernourished animals are more susceptible to infections and disease. Therefore, the participants proposed pathogens such as *Campylobacter* and *Salmonella* could be a risk for poultry.

## Heatwave

Heatwaves are defined as a prolonged period of unusually hot weather, often accompanied by high humidity (3) Heatwaves can have a profound impact on the food sector by promoting the emergence and spread of pathogens through various mechanisms, including faster bacterial growth (especially within processing environments), disruptions to refrigeration systems (cold chain infrastructure), increased need for import following higher mortality rates in livestock, and riskier consumer behaviour. The reasoning of the participants was that during heatwaves, there is an increased demand for electricity (air conditioning and cooling systems) which may lead to power outages or energy shortages. When refrigeration fails, perishable chilled foods are exposed to higher temperatures, allowing pathogens to multiply. Even short periods of exposure to temperatures above refrigeration thresholds can lead to growth of pathogen microorganisms.

## Conclusion

Different food sectors will face significant challenges during severe weather conditions that may lead to the emergence of microbiological concerns in food products reaching consumer. The participants identified crops, and RTE fruit and vegetables as the most vulnerable sectors to microbial contamination during flooding, drought, and heatwaves. The participants highlighted that VTEC/STEC are the contaminating microorganisms that pose the most significant risk to crops, and RTE fruit and vegetables during flooding and drought. This is due to the increased potential for insufficient and unsanitary farming practices and a

lack of adequate processing during the extreme weather events to eliminate the contaminating pathogens. However, *Listeria* was found to pose the most significant risk to chilled food during a heatwave. The reasoning behind this emerging risk included disruptions to the cold chain systems. However, other food sectors (poultry, beef, fish, shellfish, dairy, and imported eggs) are also at risk of emerging microbiological issues because of severe weather conditions due to environmental factors, the potential for insufficient hygiene practices, reliance on infrastructure (cold chain) and livestock health (e.g., malnutrition, stress). Therefore, monitoring the emergence of microbes during adverse weather and identifying opportunities for mitigation will help provide security for robust food sectors.

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# Bibliography, Annexes

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**Annex**

# Annex 1

ACMSF Horizon scanning workshop June 2024 (collated responses from committee members prior to discussion).

**Member A:**

## 1. Oceans

Becoming warmer and more acidic (dissolved carbon dioxide) – impact on marine life pathogen uptake and survival, including fish and shellfish e.g. Vibrio, norovirus.

Risk of changes in ocean currents bringing more pathogens to vulnerable food harvesting shorelines e.g. increased *Vibrio vulnificus* in shellfish on the US Eastern Seaboard.

## 2. Terrestrial environments and crops

Generally becoming warmer and increasing carbon dioxide and nitrous oxide–

Affecting plant and animal resilience to infection.

Affecting pathogen physiology and resilience e.g. in manure, soil, heat-stressed animals.

Increased rainfall and flood – water splashing of natural pathogens (e.g. *Listeria*) and faecal pathogens (e.g. *E. coli*, *Salmonella*, *Campylobacter*) onto crops; and transfer into irrigation water to contaminate crops.

Drought – Affecting plant and animal resilience to infection.

Conversely - Increased risk of colder winters.

Enhanced pathogen survival in manure, soil and irrigation water.

## 3. UK Domestically produced food vs imported food

These scenarios are all possible in the UK but will probably be exacerbated for other countries where the UK relies on importing a lot of food. This will require enhanced food checks.

## 4. Other

Climate stressed pathogens in food might require new methods of detection other than current “gold standard” culture methods e.g. sampling animals during husbandry, harvested crops, manures and irrigation water.

Climate change will inevitably lead to altered animal and bird migration with the risk of bringing different pathogens into a region where food animals and crops are grown.

**Member B:**

I anticipate an increase in *L. monocytogenes* outbreaks, both factory and home; as well as emergence in foods where it is not commonly found. Higher cost of water, heating and disinfection chemicals coupled with wetter and warmer seasons.

**Member C:**

Climate change is causing problems with both flooding and food supply for livestock and I think this may result in:

- Muddy, dirty cows leading to increased risk of contamination of milk with faecal organisms such as *Salmonella,* VTEC, *Listeria*, this is of particular concern in England where the sale of unpasteurised milk remains legal, so additional mitigations or monitoring for this sector may be sensible.
- Contamination of food crops with pathogens from livestock as a result of flooding.
- Higher food costs leading people to take more risks eating products beyond their sell by date, so increased risk of food poisoning events such as *Salmonella, Listeria*, VTEC.

The other major impact may be the maintenance of the cold chain in distribution of foodstuffs, and warmer environments for normally shelf stable items, so worries are:

- increased risk of *Salmonella* cases from imported eggs.

- more rapid multiplication of foodborne pathogens in normally safe foodstuffs, so normally valid use by dates are too long.

**Member D:**

1. *Campylobacter* in poultry, raw milk and raw milk cheese – warmer, wetter weather favours survival and spread of *Campylobacte*r.
2. STEC, *Salmonella*, viruses (norovirus, Hep A and maybe Hep E) in irrigation water: fresh produce (RTE fruit and veg) – wetter weather see's increased run off from land and use of sewage sludge/biosolids on land (sustainability) might be an increased source.
3. *Vibrio* spp in shellfish – decreasing salinity and increasing temperature of sea water.
4. *Listeria monocytogenes* in chilled foods – chilling may need to become a wider preservation technique as ambient temperatures rise.
5. STEC in beef/Dairy – influence on rumen flora of feed additives used to combat Methane production in cattle e.g. red seaweed.

**Member E:**

The impact of higher temperatures on the cold chain from farm to fork and how higher temperatures will put pressure on existing refrigeration systems including domestic fridges and thus allowing pathogens more opportunity to grow.

**Member F:**

Climate change and shifts in the source of cereal and protein sources for animal feeds could mean greater risk of *Salmonella* contaminated product of animal origin.

Greater animal carriage of *Salmonella* – may lead of course to increase RPF contamination and pose a significant risk of infection introduction to the domestic household.

Climate change and resultant changes in farming focusing on environmental conservation activities poses a risk of lower production profits and potential cutting corners when it comes to preventative care including vaccine use and appropriate C and D – increased disease risks.

Also, more likelihood of diversification and potential for public contact with animals /animal environments – increase STEC cryptosporidium, *Campylobacter, Salmonella* risks.

Climate and financial climate changes – more holidaying in the UK as opposed to abroad and as above increased potential for contact with animals' or animal environments.

Changing vector populations – both geographically and active times – more risk of human exposure to vector borne diseases.

In addition, I think we need to consider the potential stress the animals (especially those raised outdoors) might be subjected to and how this might increase their susceptibility to disease. Heat stress resistant strains of bacteria might also be more virulent or carry more AMR determinants. Therefore, heat could select for more public health critical strains. Disinfectants change their efficacy with heat. Vermin might increase (thinking of flies and rodents specifically for *Salmonella*) with changing environmental conditions. Increased wildlife contact with livestock might occur.

**Member G:**

Another area I would like to suggest - And one that I do think gets overlooked is the methods and techniques of Food Safety verification required by Regulation (EU) 1169 on Official Controls. This applies to EH Depts and to Vets. However, the same considerations are germane to FBOs in terms of 1st Part Verification and to the Food Audit industry in terms of Third-Party Verification.

Food Safety inspections and Audits lack scientific rigour: They are based upon notions of compliance with Food laws which have been intentionally designed to be "horizontal" and "generic" in application. This for good reason i.e to not constrain innovation in the food sector and to facilitate the working of the single market in food. However, those same design features do not support the scientific method. The laws lack precision and do not provide accurate metrics of Food Safety for the inspector or the auditor. The focus on compliance drives emphasis on the infrastructure requirements which do not feature in the epidemiology of food borne illness and does not drive an understanding of the Food Science and Technology of the processes nor their hazard and control profiles.

This problem has persisted for many years but is once again emergent with the challenges of verifying minimally processed foods such as biltong, charcuterie, raw cheese, cold smoked vacuum-packed fish, sushi, sashimi, and various fermented foods.

**Member H:**

| Scenario | Impact | Secondary impact | Effect on humans |
|---|---|---|---|
| Drought & flooding | crop failure | | food shortage |
| Heat and very wet | climate control failure in animal buildings | animal death & disease | food shortage and risks to humans |
| Heat | shortage of electricity | | |
| Heat | climate control failure in animal buildings | animal death & disease | food shortage and risks to humans |
| Heat | failure of food processing or refrigeration systems | | food shortage and risks to humans |
| | failures of mains water supply | | human health and disease, increased risks of unsanitary conditions |
| Floods | contamination of crops and fresh water systems and factories | | spread disease to humans |
| Algal Blooms | affect fish and shellfish | | risks to humans |
| Legionella | | | risks to humans |

# Annex 2

Table 1 participant consensus on the key risks (emerging microbiological issue) for food sectors in relation to flooding.

| | E. coli | Campylobacter | Listeria | Norovirus | Salmonella | Vibrio | Viruses (e.g. HepA, HepE) | VTEC/S |
|---|---|---|---|---|---|---|---|---|
| **Fish** | | | | | | | * | |
| **Shellfish** | | | | **5** | | | * | * |
| **Beef** | | | | | * | | | * |
| **Poultry** | * | | | | * | | | |
| **UK Eggs** | | | | | | | | |
| **Dairy (including milk and cheese** | | | * | | | | | * |
| **Raw milk/raw milk cheeses** | | | * | | | | | * |
| **Imported Eggs** | | | | | | | | |
| **Crops** | | | * | | * | | * | **10** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **RTE fruit and Veg** | 8 | 6 | 7 | | *[1] | **9** |
| **Chilled Foods** | * | | | | | |

[1] risk identified as between 10 and 5, i.e. lower than those ranked but not quantified further are marked with an Asterix.

# Annex 3

Table 2 participant consensus on the key risks (emerging microbiological issues) for food sectors in relation to drought.

| | **E. coli** | **Campylobacter** | **Listeria** | **Norovirus** | **Salmonella** | **Vibrio** | **Viruses (e.g. HepA, HepE)** | **VTEC/S** |
|---|---|---|---|---|---|---|---|---|
| **Fish** | | | | | | | | |
| **Shellfish** | | | | | | | | |
| **Beef** | | | | * | | | | * |
| **Poultry** | * | | | * | | | | |
| **UK Eggs** | | | | | | | | |

| | | | |
|---|---|---|---|
| **Dairy (including milk and cheese** | | | |
| **Raw milk/raw milk cheeses** | * | * | *[1] |
| **Imported Eggs** | | | |
| **Crops** | 8 | | 10 |
| **RTE fruit and Veg** | 7 | | 9 |
| **Chilled Foods** | | | |

[2] risk identified as between 10 and 7, i.e. lower than those ranked but not quantified further are marked with an Asterix.

# Annex 4

Table 3 participant consensus on the key risks (emerging microbiological issues) for food sectors  in relation to heatwave.

| | **E. coli** | **Campylobacter** | **Listeria** | **Norovirus** | **Salmonella** | **Vibrio** | **Viruses (e.g. HepA, HepE)** | **VTEC/S** |
|---|---|---|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **Fish** | | * | | * | |
| **Shellfish** | | * | | * | |
| **Beef** | | | | | * |
| **Poultry** | * | | * | | |
| **UK Eggs** | | | | | |
| **Dairy (including milk and cheese** | | * | * | | * |
| **Raw milk/raw milk cheeses** | | * | * | | * |
| **Imported Eggs** | | | *[1] | | |
| **Crops** | | | | | 8 |
| **RTE fruit and Veg** | | | | | 9 |
| **Chilled Foods** | | 10 | | | |

[3] risk identified as between 10 and 8, i.e. lower than those ranked but not quantified further are marked with an Asterix.