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Bibliography

Laboratory NNSS. Flood Basics 2024 Severe Weather 101: Flood Basics

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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.