

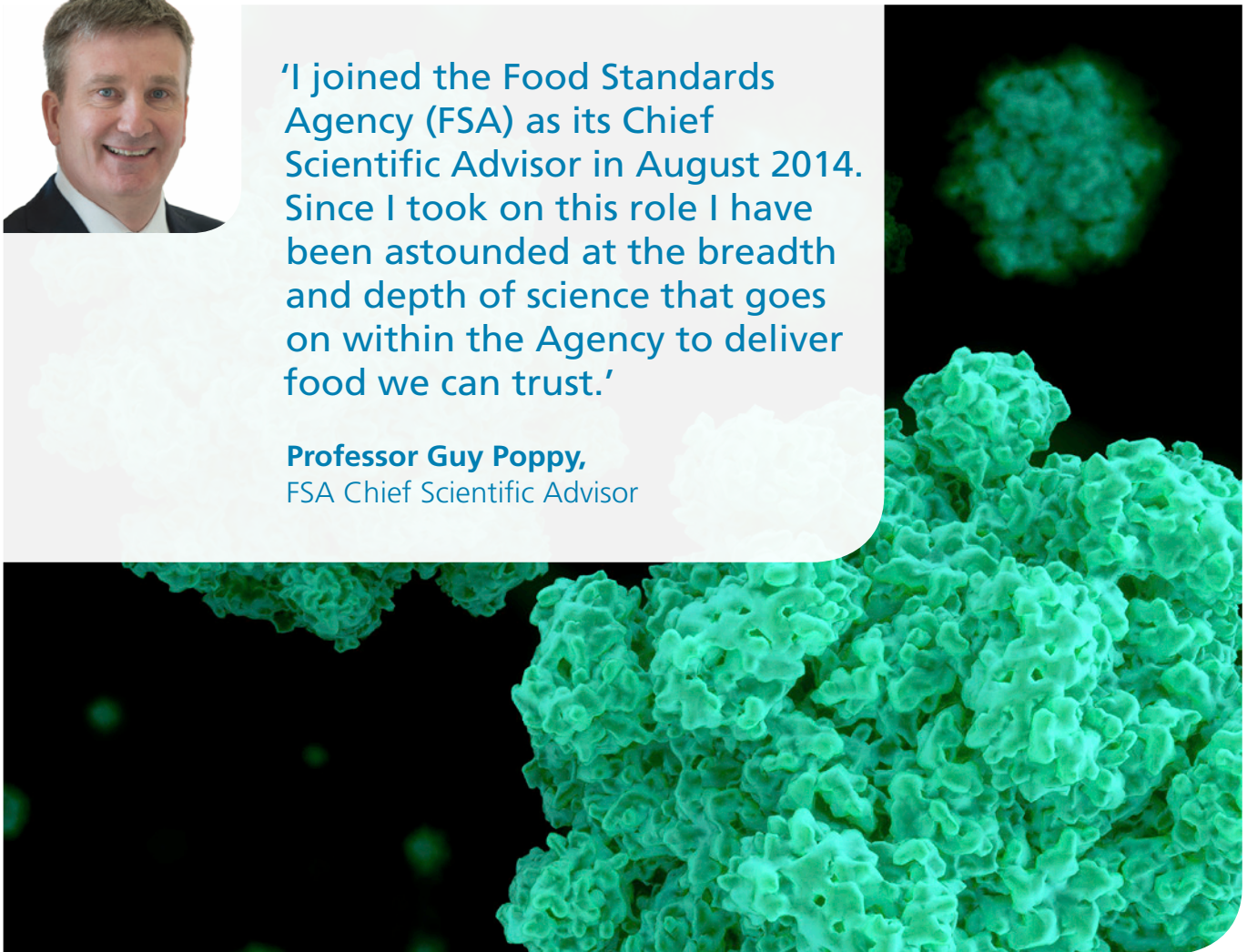
Chief Scientific Advisor's Science Report

Issue One: Foodborne Viruses



'I joined the Food Standards Agency (FSA) as its Chief Scientific Advisor in August 2014. Since I took on this role I have been astounded at the breadth and depth of science that goes on within the Agency to deliver food we can trust.'

Professor Guy Poppy,
FSA Chief Scientific Advisor



'At the FSA it is no exaggeration to say that science is at the very heart of what we do. Our science informs our policy work. It is what we use to help us to scan the horizon for new risks; it is what informs our advice to members of the public and food businesses and it is what drives us to understand how we can better protect UK food and UK consumers.'

'That said, science does not always give us all of the answers we need at any one time. We are an organisation that is entirely committed to being open about where there are gaps in our knowledge and doing what we can to move forward on the basis of the best evidence available.'

'I am delighted to be introducing this report, the first of a series of regular updates that I hope will give you a greater understanding of our science and help to lift the lid on some of the cutting edge work that goes on within the FSA - work that you might not otherwise hear about and work that may not always generate headlines. Each edition will focus on a current topic and include updates on other issues of note.'

At the FSA it is no exaggeration to say that science is at the very heart of what we do

'In this report we turn the spotlight on viruses in food - what they are, how they cause disease, how we are working with others to apply science to understand them, how to reduce the risks and, importantly, why this is no easy task. We also take a broader look at the FSA's overall strategy for science and finally we touch upon the issue of antimicrobial resistance.'

'I hope this provides an insight into some of the science work we do. I want these reports to provide useful information, but it should not end there. I want to encourage debate on the issues we look at and the way we use science to understand and address them.'

Introduction

We know that bacteria, such as campylobacter, salmonella and listeria, contribute significantly to the number cases of foodborne illness in the UK. However the contribution of foodborne viruses is less clear.

This report explains how the Food Standards Agency (FSA) uses science, evidence and analysis to control food safety risks related to viruses; particularly norovirus and hepatitis E virus. It also looks at hepatitis A virus, cases of which have been decreasing in the UK over the past few years.

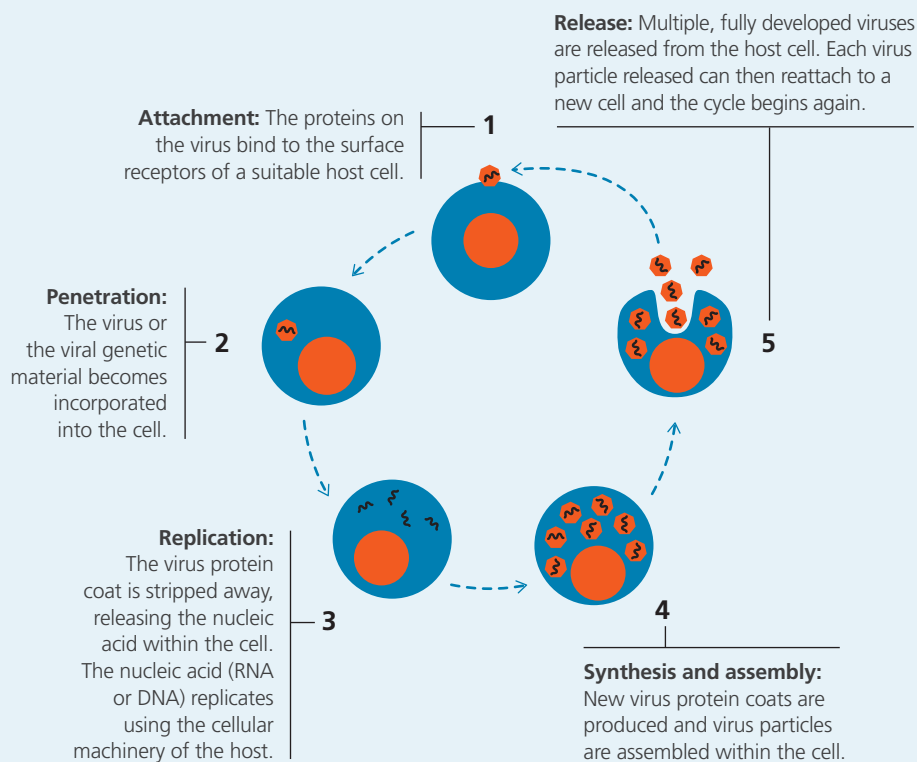
Norovirus (NoV), which is known as the winter vomiting bug, is estimated to cause 3 million cases of diarrhoea and vomiting illness in the UK every year, a proportion of which are foodborne. There is also increasing evidence of an emerging risk of hepatitis E virus (HEV) infection potentially linked to undercooked pork and pork products.

The FSA is contributing to developing analytical methodology to distinguish viruses which are infectious from damaged or non-infectious viruses as well as conducting studies into the heat stability of HEV. We are also addressing gaps and uncertainties in the science and evidence.

Foodborne virus facts

Replication of viruses

During the process of replication, a virus uses a living cell to produce the essential components for new viral particles.



How big is a foodborne virus?

A human hair is roughly...

80x

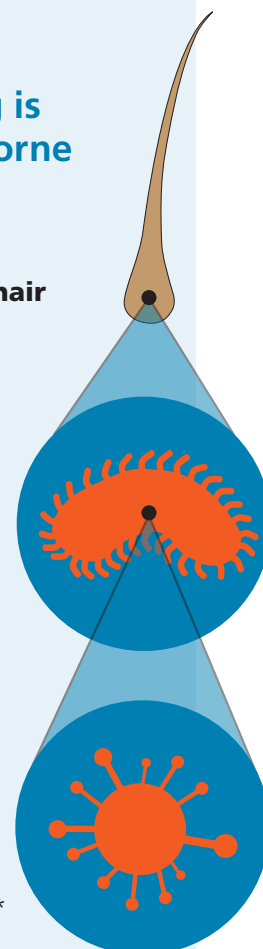
a **bacteria** which is...

30x

a foodborne **virus** which is around

30
nanometres*

* a nanometre is one million times smaller than a millimetre.

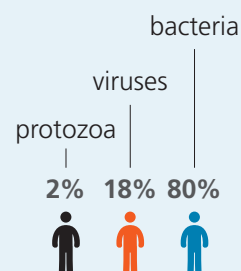
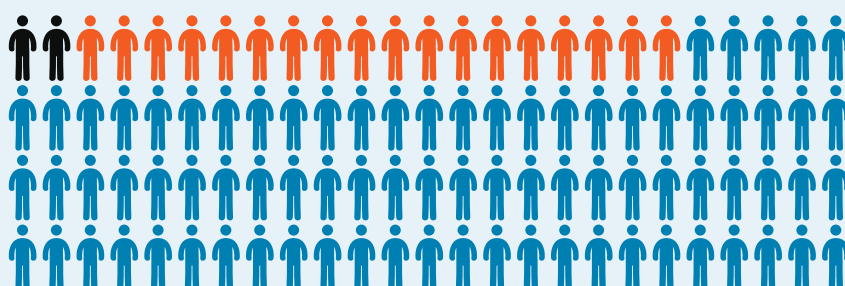


Survival and spread

Viruses have the ability to survive and remain infective in foods and the environment for prolonged periods of time. Viruses can be spread between hosts in different ways such as through bodily fluids, the gastrointestinal tract and air, depending on the type of virus involved.

Foodborne illness by bacteria, protozoa and viruses in 2009

(based on 13 pathogens included in the IID2 extension study)



What are viruses?

Viruses are tiny, often highly contagious pathogenic (disease-causing) agents, composed of a segment of RNA or DNA enclosed in a protein coat known as a capsid. Unlike bacteria, viruses are not technically considered living organisms because they are devoid of biological machinery. In some cases they demonstrate a high degree of resistance to environmental stressors such as heat, extremes in pH, and UV exposure.

What are foodborne viruses?

Enteric viruses are transmissible by food and water and enter the body through the gastrointestinal tract. These viruses make a significant contribution to the overall burden of foodborne illness in the UK. A study¹, published by the FSA in June 2014, estimated that viruses are responsible for 18% of UK foodborne disease.

Foodborne viruses are spread through the faecal-oral route; they are shed in high concentrations in faeces and vomit and can remain infectious in the environment for several months. Food can become contaminated by viruses at source and through contaminated food handlers and environments. Good food hygiene and personal hygiene, especially hand washing, is therefore essential to help minimise the spread of these viruses within the food chain. Since foodborne viruses tend to be more resistant to physical and chemical treatments than bacteria, their control represents a real challenge for the food industry.



¹The IID2 extension study aimed to improve the estimation of the burden of foodborne disease in the UK and to identify the most common sources of illness – both in terms of pathogen and food commodities – http://www.foodbase.org.uk/results.php?f_category_id=&f_report_id=866

What is norovirus?

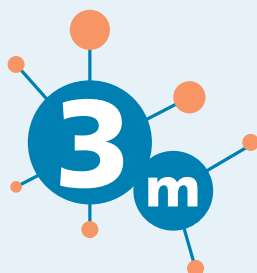
Norovirus is commonly known as the winter vomiting virus and the symptoms can be severe diarrhoea and projectile vomiting.

It is usually short lived and people get better without medical treatment.

Norovirus facts



Norovirus is highly contagious and is the **leading cause** in the UK of infectious intestinal disease (IID), otherwise known as diarrhoea and vomiting.



Each year norovirus is responsible for an estimated **3 million cases** of diarrhoea and vomiting.



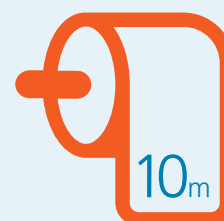
For every case of norovirus reported there are an estimated **290 unreported cases** in the community.



Norovirus is estimated to be the **third most common** foodborne pathogen in the UK.



It is estimated that in 2009 norovirus in food was responsible for **74,000 cases**, **3,300 GP consultations** and **300 hospital admissions**.



Around **10 million** norovirus particles can be found in a gram of faeces from an infected person. It can take as few as **10 virus particles** to make someone ill.

*All figures taken from the FSA's report on IID2 and the IID2 extension and relate to cases in 2009

How is norovirus spread?

Direct person-to-person transmission is considered to be the main route of spread, although contaminated foods and food handlers are also likely to be important routes of infection.

Good hygiene, especially hand-washing, is essential in reducing the spread of norovirus.



Norovirus

Norovirus (NoV), like other viruses, cannot multiply in food. However, it can survive in food and the environment for prolonged periods of time. Good food and personal hygiene, especially hand-washing, are essential in reducing the spread of NoV and other viruses.

Evidence of norovirus in the food chain

NoV often causes outbreaks, some of which may be foodborne. Research funded by the FSA estimated that NoV was responsible for 74,000 cases of food poisoning in the UK in 2009. Raw or undercooked bivalve molluscs (e.g. oysters), fresh produce (berries and salads) and infected/contaminated food handlers have previously been implicated in foodborne NoV outbreaks. An FSA funded survey (FS235003), published in 2011, found that 76% of oysters sampled from oyster harvesting sites across the UK were contaminated with NoV, although the study was unable to determine whether the NoV detected was infectious or not.

Hepatitis E Virus

Hepatitis E is an infection and inflammation of the liver caused by hepatitis E virus (HEV), which can infect both animals and humans. HEV infection usually produces only mild disease but in rare cases it can prove fatal, particularly in vulnerable groups. Typical symptoms of hepatitis include self-limiting jaundice (yellowing of the skin and eyes, darkening of urine and pale stools), loss of appetite, an enlarged and tender liver, abdominal pain, tiredness, fever, nausea, diarrhoea and vomiting. The disease usually clears within four weeks.

HEV infection usually produces only mild disease but in rare cases it can prove fatal

Historically, the majority of hepatitis E cases reported in the UK were non-UK acquired and associated with the consumption of contaminated food and water following travel to parts of Asia, Africa and Central America where sanitation may often be poor. However, in recent years the number of hepatitis E cases has increased within industrialised countries, including the UK, and involving people who have not travelled abroad (see Figure 1). The majority of hepatitis E cases in the UK today are non-travel related.

Evidence of hepatitis E in the food chain

Although HEV is transmitted via the faecal-oral route there is increasing evidence that it is a foodborne zoonosis². A survey within pig abattoirs found that 93% of pigs tested had antibodies for HEV indicating that they had previously been exposed to the virus. However, 5.7% were found to have HEV in their blood and were therefore likely to be

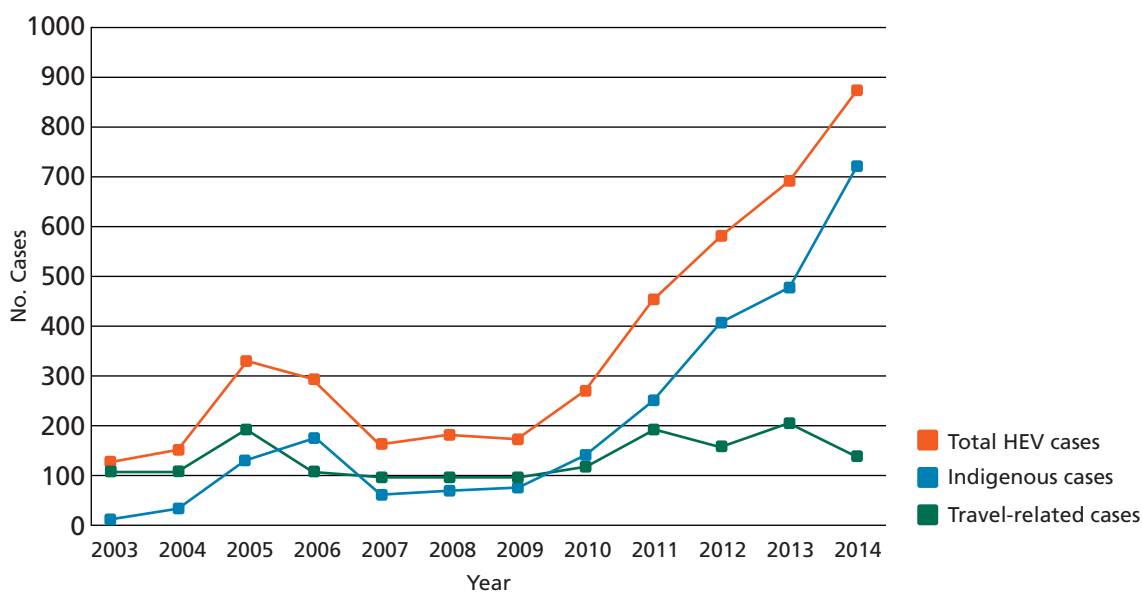
²Zoonoses are infections or diseases that can be transmitted directly or indirectly between animals and humans, for instance by consuming contaminated foodstuffs (foodborne zoonoses) or through contact with infected animals.

infectious at the time of slaughter. Epidemiological investigations have linked undercooked pork and pork products to illness with HEV however, the presence of the infectious virus itself in undercooked pork has not been determined. As part of an EU FP7 project called VITAL the Animal and Plant Health Agency (APHA) found that 2.5% of pig livers and 10% of sausages were contaminated with HEV, although these findings need to be interpreted with caution as the sample size was small and not representative of the UK market and the majority of the HEV positive sausages were from the same batch.

It should be noted that the emergence of a particular type of HEV in people in England and Wales appears not to be the same strain of HEV typically seen within UK pigs. The FSA is continuing to work in partnership to investigate what is driving the recent increase in indigenous³ hepatitis E cases in the UK.

As a precaution, the FSA advises that all whole cuts of pork, pork products and offal should be thoroughly cooked until steaming hot throughout, the meat is no longer pink and juices run clear. This will potentially reduce any risk of illness from HEV, and other foodborne pathogens. Good hygiene practices and hand washing are also important to reduce the risk of cross-contamination within the kitchen.

Figure 1 – Hepatitis E reference laboratory confirmed cases, England and Wales, 2003-2014 (Source: PHE, 2015)



³Indigenous: Occurring naturally in a particular region or environment

Case study

1. Determining the infectivity of norovirus and hepatitis E virus

- **What is the science telling us?** At present there is no way of measuring whether the NoV or HEV found in food is infectious and therefore capable of making us ill.
- **What is the FSA doing about it?** Exploring whether current laboratory detection methods can be modified to allow us to differentiate between infectious and non-infectious NoV and HEV.
- **What will this enable us to do?** Inform our risk assessment for these viruses within the food chain and allow us in the long term to target our interventions to stop them from reaching our dinner plates.

Viruses are difficult to culture as they only replicate within living host cells. Culture methods are available for hepatitis A virus (HAV), these are less developed for HEV and currently none are available for NoV. Detection and analytical methodology for these viruses relies upon molecular methods. Real Time Polymerase Chain Reaction (RT-PCR) is currently used to identify viral genomic material in food.

The inability to culture NoV means that surrogates (substitutes) such as mouse forms of NoV or RNA bacteriophages are often used for research but these viral models may not correlate well with foodborne NoV. This introduces further uncertainty in the interpretation of research findings. The European Food Safety Authority (EFSA) panel on Biological Hazards reported in 2011 that the food matrix or substrate and host factors can also influence the level of infectivity.

What the FSA is doing?

Foodborne viruses have a significant impact on public health and this is recognised in our Foodborne Disease Strategy (FDS).

There remain a number of knowledge gaps in terms of how NoV, HAV and HEV are transmitted through the food chain, the contribution they make to overall foodborne illness and their survival and elimination from food. The FSA has embedded a

**Foodborne viruses
have a significant
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health**

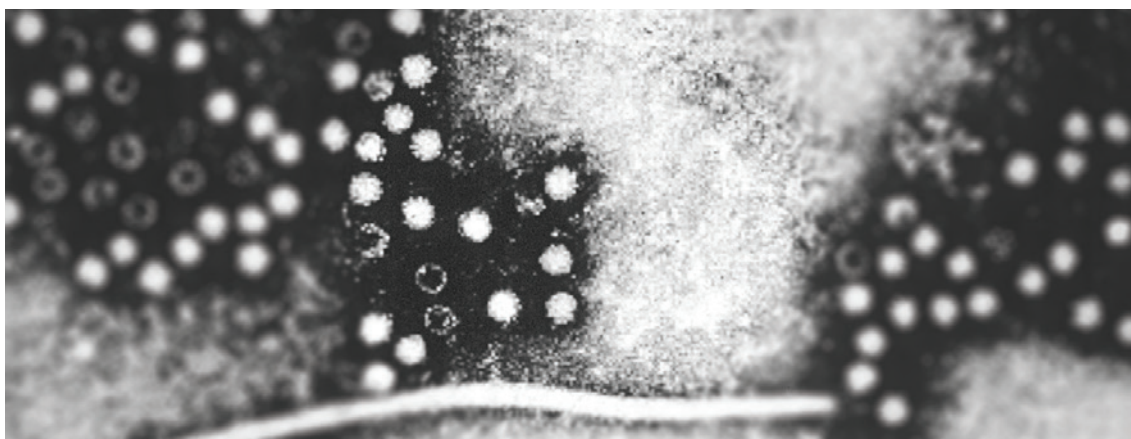
foodborne viruses research programme within the FDS to address these gaps in our knowledge.

In addition, we are currently funding a study to assess the contribution made by the food chain to the burden of UK-acquired NoV infection. This Norovirus Attribution Study (NoVAS) includes specific work to further develop a method to distinguish between infectious and non-infectious NoV particles in oysters and fresh produce (raspberries and lettuce), based on assessing the integrity of the capsid. The NoVAS study started in January 2014 and is due to complete in 2017.

The NoVAS project will help us to understand more about NoV. From a risk assessment perspective this will mean we can establish where infectious NoV occurs in the food chain, where consumers are exposed to NoV and at what levels. This will allow more focussed efforts to control the exposure of humans to NoV capable of causing gastrointestinal disease and reduce the number of foodborne cases.

The FSA continues to work in partnership with other stakeholders and leading experts both within the UK and internationally, in addition to keeping up to date with new and emerging information in the scientific literature to inform our work in this area.

Our Advisory Committee on the Microbiological Safety of Food (ACMSF) recently reviewed the evidence on viruses in the foodchain. The report, published in March 2015, makes a number of recommendations to the FSA, Public Health England (PHE), Centre for Environment, Fisheries and Aquaculture Science (Cefas), the Environment Agency (EA) and the Department for Environment, Food and Rural Affairs (Defra) on NoV, HEV and HAV.



Case study

2. The effects of heat on the inactivation of hepatitis E virus

- **What is the science telling us?**

There is currently a degree of uncertainty about the effectiveness of conventional cooking practices as a means of eliminating infectious HEV from contaminated meats and meat products (such as pork sausages). Research (FSA Project FS101074) suggests that HEV may generally be more heat resistant than bacteria and therefore cooking, which is effective in eliminating bacteria in food, may not be as effective at inactivating HEV.

We need to develop a clear evidence base in this area to address concerns from both industry and consumers.

- **What is the FSA doing about it?** Commissioning further laboratory-based research on the heat stability of HEV *in vitro* and in meats and meat products.
- **What will this enable us to do?** Address a significant knowledge gap in terms of defining what temperature/time parameters are required to destroy HEV in food and whether our current cooking advice is sufficient or if it needs to be amended; this is important for risk management purposes. We need to develop a clear evidence base in this area to address concerns from both industry and consumers.

Much attention has been paid to the effect of heating on the infectivity of HEV. However, drawing definitive conclusions from the current evidence is challenging due to different methodologies and study designs.

Barnaud *et al.* (2012) examined the effect of heat on HEV in pig liver preparations using various times and temperatures followed by inoculation of heat treated preparations into pathogen-free pigs. They reported that heating contaminated liver to an internal temperature of 71°C for 20 minutes was necessary to demonstrate complete inactivation of HEV. However, a recent FSA funded review (FS101074) suggested that due to experimental design there may have been an overestimation of the stringency of heat treatment required. This means further work is needed.

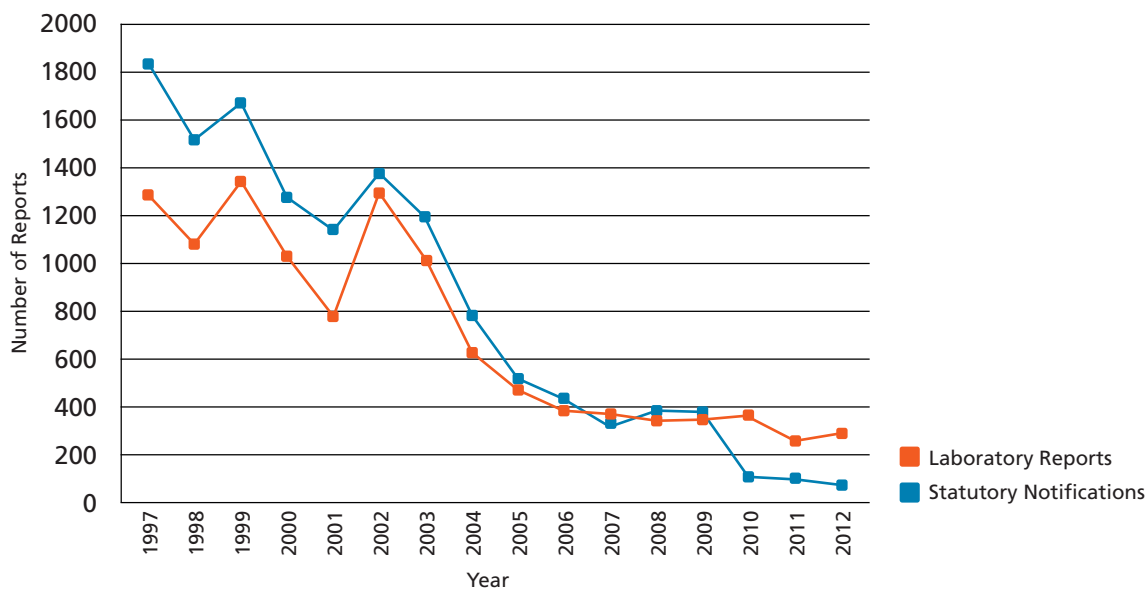
There is very little data on the actual levels of HEV in retail foods with which to assess the impact of these heating treatments. For example, a recent Canadian study found high levels of the virus in retail pigs liver which contrasted with the low levels found in pork chops.

Hepatitis A Virus

Hepatitis A is an acute infectious disease of the liver caused by the hepatitis A virus (HAV). Many hepatitis A cases have few or no symptoms, especially in the young. The incubation period (time between exposure and onset of symptoms) is between two and six weeks. When there are symptoms, they typically last eight weeks and are similar to hepatitis E infection and may include nausea, vomiting, diarrhoea, fever, and abdominal pain. Acute liver failure may rarely occur. This is more common in older people.

HAV is spread by the faecal-oral route. It is usually spread by eating or drinking food or water contaminated by faeces containing virus. This occurs mainly in developing countries where poor sanitation and overcrowding exists. In industrialised countries person-to-person transmission is rare and outbreaks of HAV infections are associated with spread via contaminated foods. The virus is shed in high numbers in faeces and the long incubation period in which shedding occurs contributes significantly to outbreaks, particularly those associated with food handlers. Outbreaks have been previously associated with the consumption of fresh produce (e.g. soft berries) and raw/inadequately cooked shellfish cultivated in contaminated waters.

Figure 2 – Hepatitis A laboratory reports and statutory notifications, England and Wales, 1997-2012 (Source: ACMSF Virus report, 2015).



HAV infections in the UK are rare with the number of reported cases in England and Wales falling over the past decade (see Figure 2). In May 2013 Germany and Italy reported an outbreak of HAV linked to the consumption of berries. Further investigations led to the identification of a multinational outbreak with cases reported in Denmark, Finland, France, Germany, Ireland, Norway, the Netherlands, Poland, Sweden and the United Kingdom. Overall 331 cases were reported. HAV was detected in frozen mixed berries and mixed berry cakes/pastries in Italy, France and Norway.

Conclusion

Emerging trends indicate that viruses play an important role in foodborne illness. This has implications for the whole of the food chain.

We will continue to closely monitor this area and will keep current and future scientific evidence under review in order to develop a strategy to tackle foodborne viruses based on the best evidence available.



Using science to deliver food we can trust: a new strategy and a new approach



The FSA is developing its Science, Evidence and Information Strategy 2015-20 (SEI Strategy), drawing on expert input and analysis and discussion across the Agency and with stakeholders. The SEI Strategy will set out how we will use science, evidence and information to help to shape, deliver and evaluate progress on the FSA's strategic objectives, as set out in the FSA Strategy for 2015-20. The SEI Strategy will also take a longer-term view, helping us to understand risks and opportunities, the potential of new technologies and of big data and to build capability to deliver in the longer term.

The SEI Strategy is based on a vision for the FSA's science and two sets of priorities. The first set looks at the areas of science we need to develop and apply including assessing and managing risks, better use of data, understanding consumers, businesses and behaviour change, and learning from what does and doesn't work. The second set of priorities looks at how we conduct our science including building skills and capabilities, ensuring quality, communicating and using science to maximise impact, and building strategic partnerships. We will use this framework to develop a Delivery Plan, which will set out in more detail the specific programmes of science work.

The SEI Strategy highlights the importance of work with others to share information, understand the issues, and to shape and deliver our science programmes. We will continue to work with our partners and stakeholders to develop the Delivery Plan, and to implement it in the years to come.

Antimicrobial Resistance



Antimicrobial resistance (AMR) is a major public health concern. It is a complex issue driven by a variety of interconnected factors enabling microorganisms to withstand antimicrobial treatments to which they were once susceptible. The overuse and/or misuse of antibiotics has been linked to increasing the emergence and spread of microorganisms which are resistant to them, potentially rendering treatment ineffective and posing a risk to public health. Modern medical and veterinary practice relies on the widespread availability of effective antimicrobials to prevent and treat infections in humans and animals. If the number of hard-to-treat infections continues to grow it will become increasingly difficult to control infection in a range of routine medical care settings and it will be more difficult to maintain animal health and protect animal welfare.

The FSA has a keen interest in the potential for food to be a vehicle for the transmission of antimicrobial resistant bacteria and has several strands of research and work in place geared towards improving our understanding of these risks to public health. This includes development of a detection method for Extended Spectrum Beta Lactamase (ESBL)-producing bacteria and the prevalence and levels of AMR bacteria in retail meats. We will be shortly commissioning a systematic review of the available literature to assess the contribution that food makes to the problem of AMR bacteria in humans. The issue of AMR within the food chain will be covered in a future edition of the Chief Scientific Advisor's Report.

Further Reading

For further information on viruses please see:

Advisory Committee on the Microbiological Safety of Food (ACMSF). An update on viruses in the food chain. March 2015. <http://acmsf.food.gov.uk/acmsfrepos/acmsfreports>

Barnaud E, Rogee S, Garry P, Rose N, *et al.* Thermal inactivation of infectious hepatitis E virus in experimentally contaminated food. *Appl. Environ. Microbiol.*, 2012; **78**(15): 5153-5159.

European Food Safety Authority (EFSA)

Tracing of food items in connection to the multinational hepatitis A virus outbreak in Europe. <http://www.efsa.europa.eu/en/efsajournal/doc/3821.pdf>

Food Standards Agency (FSA)

Proceedings of the Food Standards Agency's Foodborne Viruses Research Conference 15-16 January 2013, London.

<http://www.food.gov.uk/sites/default/files/multimedia/pdfs/publication/foodborne-virus-2013.pdf>

<http://www.food.gov.uk/sites/default/files/fsa141105a.pdf>

FS101040. FSA project report. Assess the contribution made by the food chain to the burden of UK acquired norovirus illness (NoVAS study). <http://www.food.gov.uk/science/research/foodborneillness/b14programme/b14projlist/fs101040>

FS101074. FSA project report. A critical review of the effects of heat, pH and water activity on the survival of hepatitis A and E viruses.

http://www.foodbase.org.uk/results.php?f_category_id=&f_report_id=882

FS101097. FSA research call. Heat stability of hepatitis E virus in vitro and in meat and meat products.

<http://www.tendersdirect.co.uk/Search/Tenders/Print.aspx?ID=%20000000004817153>

FS231043. FSA project report. The second study of infectious intestinal disease in the community (IID2 Study). http://www.foodbase.org.uk/results.php?f_report_id=711

<http://www.food.gov.uk/science/research/foodborneillness/b14programme/b14projlist/b18021>

FS231043 Extension. FSA project report. Costed extension to the Second Study of Infectious Intestinal Disease in the Community: Identifying the proportion of foodborne disease in the UK and attributing foodborne disease by food commodity. http://www.foodbase.org.uk//admintools/reportdocuments/866-1-1609_IID2_extension_report_-_FINAL_25_March_2014.pdf

<http://www.food.gov.uk/science/research/foodborneillness/b14programme/b14projlist/fs231043ext>

FS235003. FSA project report. Investigation into the prevalence, distribution and levels of norovirus titre in oyster harvesting areas in the UK. <https://www.food.gov.uk/science/research/foodborneillness/p01programme/p01projlist/p01009>

OZ0150: Salmonella, Toxoplasma, Hepatitis E virus, Yersinia, Porcine Reproductive and Respiratory Syndrome virus, antimicrobial resistance in Campylobacter and extended spectrum beta lactamase E. coli in UK pigs at slaughter (Pig Abattoir Survey). Final report is available on the Defra website and can be accessed at: <http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=16871&FromSearch=Y&Publisher=1&SearchText=OZ0150&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description>

European Food Safety Authority (EFSA) Scientific Opinion on an update on the present knowledge on the occurrence and control of foodborne viruses.

<http://www.efsa.europa.eu/en/efsajournal/pub/2190.htm>

For further information on the Government's work on AMR please see:

<https://www.gov.uk/government/collections/antimicrobial-resistance-amr-information-and-resources>

For more information, visit: food.gov.uk

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