The Lion Code approach to control and prevention of salmonella in the UK

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Salmonellosis remains within the top two bacterial foodborne disease in countries worldwide constituting a major international public health problem with huge industry and societal costs.

The zoonotic sources of this infection have been recognised for many years. This article will discuss the causative agents, the disease they cause, the sources of infection and, finally, how, by working together, the regulatory authorities, industry, medics, veterinarians and scientists have successfully controlled this foodborne infection in the UK.

The taxonomy of the genus Salmonella has a long and complicated history. Nevertheless, the primary causative agents of human non-typhoidal salmonellosis are of the species Salmonella enterica, subspecies Type 1. Within this group strains are differentiated by serotype and there are over 1500 identified serovars.

In the European Union the serovars S. typhimurium and S. enteritidis, are the major isolates from human infections (Fig. 1) with smaller contributions from serovars like S. heidelberg and S. infantis.

By whatever biological criteria you use the agents causing salmonellosis are highly successful bacteria. The rod-shaped Gram negative bacterium we know as Salmonella enterica evolved from a common ancestor of E. coli over the last 120 million years or so, taking up DNA in the process.

The outcome of this evolution was the development of a capacity to exploit and colonise numerous habitats including the gastrointestinal tract of warm-blooded animals. In particular, this evolutionary process enabled the bacterium to become the facultative intracellular pathogen causing non-typhoidal salmonellosis.

Foodborne disease is a worldwide problem but remains largely unrecognised in many, especially non-industrialised, countries because foodborne illness is inadequately monitored or not monitored at all. In addition, in such countries high exposure of the indigenous human population to the bacteria results in widespread partial immunity, which reduces the incidence of infection and confounds epidemiological studies.

Multiple implications

Over the last few decades, as a result of a number of food safety issues, the food production industry in the UK has undergone huge changes to address the issue of the microbiological safety of food. These changes, linked to a well structured and relatively stable public health surveillance capacity, has provided some excellent examples of the societal benefits of the integrated production of microbiologically safe food. Salmonellosis is the major success story.

The common symptoms of non-typhoidal salmonellosis are diarrhoea, fever, vomiting and abdominal cramps 12-72 hours post infection. In most cases the illness lasts 4-7 days. However, illness varies in severity and this variation is related to the dose, the serovar and the age or immune competence of the individual. In severe cases death can occur.

In 2002 Adak et al., reported that in England and Wales 3.6% of cases were hospitalised and 0.3% died. The size of the public health problem due to salmonellosis in the UK is large and the reporting of cases is mandatory. The Health Protection Agency (now Public Health England) reported 8,314 cases of salmonellosis in 2012 in England and Wales.

However, community-based studies have shown that the number of cases is significantly under-reported. This means that the true level of infections is more realistically 39,000.

Santos et al., (2011) estimated that the total cost of salmonellosis in England and Wales was UK£6.5 million per year. However, the situation used to be much worse.

Salmonella awareness

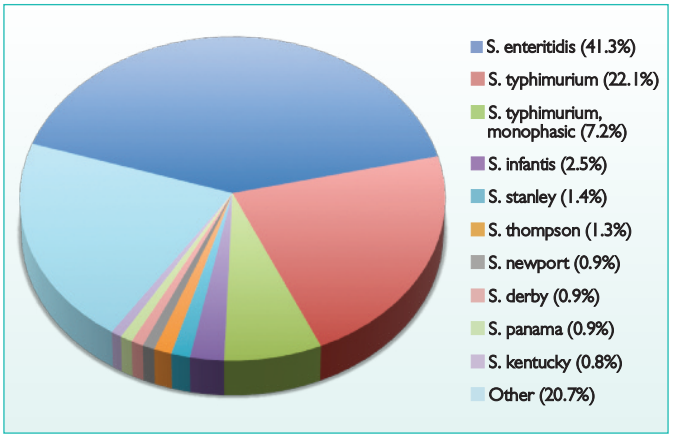
This story starts many decades ago. From 1955-1975 the total number of cases of salmonellosis was less than 5,000 per year and mostly of the S. typhimurium serovar (Fig 1). Although, the numbers slowly started to rise no real alarm was raised until 1988 when there was about a 3-fold increase in reported disease mainly due to S. enteritidis of the phage type 4 (PT4). This phage type was already known to be associated with poultry and eggs.

Epidemiological investigations quickly linked this increase to the consumption of foods containing uncooked or undercooked eggs.

The Chief Medical Officer of the day published a warning to vulnerable people, including children, pregnant women, and the elderly about eating uncooked eggs. Then Edwina Currie, a junior Health Minister, announced to 10 million television viewers that "most of the egg production in this country, sadly, is now affected with salmonella". She meant to say "egg production flocks" but it was interpreted that most eggs were affected. The poultry industry and the Ministry of Agriculture, Fisheries and Foods (MAFF) countered stating that with just 26 cases of food poisoning confirmed as being caused by eggs, the chances of infection in humans was put at one in 200m.

However, the general public reacted dramatically and almost overnight egg sales plummeted by 60%. The crisis cost the UK government nearly £8 million in compensation for 400 million surplus eggs and 4 million unwanted hens (4% of the national flock).

Fig. 1. Distribution of common serovars reported in humans in the European Union, 2012.



The Lion Code of practice

In response to the public outcry the government passed the 1989 Zoonoses Order in which all isolates of salmonella from farm animals and birds, their carcases, products, feed or surroundings were to be reported to MAFF.

This was closely followed by the Poultry Breeding Flocks and Hatcheries Order 1993. This order stated "In cases where salmonella infection is confirmed after an investigation, the flock must be slaughtered. However, in the case of a parent broiler breeder flock alternatives are offered, which include antibiotic treatment of the parent flock or its progeny."

The order specified the regular compulsory monitoring of breeding flocks of >250 birds throughout

Continued on page 17

Continued from page 15
their lifespan and hatcheries with an incubator capacity for >1,000 eggs. The bacteriological culture included composite faeces and the testing of progeny at the hatcheries using a standardised sampling protocol and laboratory method. Any flocks positive for 'invasive' strains were sent for slaughter.

The order also allowed for some optional measures including the voluntary salmonella vaccination of breeding flocks and the heat treatment of feed.

So did the power of state regulation work? Throughout 1988 to 1993 salmonellosis continued to steadily rise in Great Britain (Fig. 2). There was a temporary fall following the 1993 Order but then another steady increase. In 1991 the PHLS undertook a retail survey of chicken eggs and found that 1:650 eggs were contaminated with salmonella. In 1996 the retail survey was repeated and the contamination rate was 1:700 eggs. Clearly there had been little effect on the public exposure.

By this time it became clear to the industry that the situation was unacceptable. The scientific work undertaken by many UK laboratories, especially the Veterinary Laboratories Agency (VLA) and the PHLS, had clearly demonstrated the epidemiological link between contaminated eggs and human disease by showing that some strains of salmonella (in particular S. enteritidis PT4) were adapted to colonise the oviduct and thereby contaminate eggs and that it was largely this strain that was causing the human disease.

Vertical transmission was not the only source of the problem in poultry. The VLA and other laboratories undertook tediously detailed bacteriological surveys demonstrating the critical points of contamination in the environment around poultry houses and proving the role of horizontal transmission with vectors like feed, water, rodents and insects.

Some poultry companies started taking voluntary steps to address the problem. The British Egg Industry Council (BEIC), which was set up in 1986 by 11 major organisations concerned with egg production to represent the British egg industry and with a particular focus on marketing, became a focusing force for the demoralised industry.

In November 1998 the BEIC established and launched a Quality Assurance Scheme for eggs. Members of the scheme were allowed to market Lion Quality eggs and quickly became preferred suppliers to the retail and catering industries. The Lion Code Quality Scheme is currently used by 90% of British egg producers. Since its inception it has tested two million eggs and carried out 50,000 audits.

Standards and scope

The Lion Quality Code assured consumers and retailers that all Lion-stamped eggs are produced in Great Britain from British hens kept to the animal welfare requirements of the Royal Society for the Prevention of Cruelty to Animals (RSPCA). It also guaranteed that the hens were vaccinated, originally against S. enteritidis, and later from S. typhimurium.

There is a producer registration and unique 'passport' system, ensuring the complete traceability of the hens, eggs and their feed. The Code specified increased levels of hygiene and the salmonella testing of all flocks in the egg production chain. It also ensured regular egg testing.

Because salmonella contamination of feed was a high risk, the feed used had to be guaranteed by the Universal Feed Assurance Scheme (UFAS) standards. Finally, there was regular independent auditing of all egg producers and packing units.

All Lion Quality eggs are stamped on the farm with the farm code, production method and a use by date. Today the Red Lion stamp has a huge level of brand recognition by the general public throughout the country and this provides a high level of consumer acceptance and trust.

In 1998, at the time of the introduction of the Lion Code Scheme there were over 14,000 reported cases of human salmonellosis in England and Wales (Fig. 1). Since then there has been a year on year fall to just over 8,000 cases in 2012 suggesting that the Lion Code Scheme has been extremely successful. Of course association does not mean causation; there could be other explanations for such a fall in reporting. Nevertheless, in 2001 the Department of Health commissioned a survey of all intestinal infectious disease in England and Wales.

This survey, undertaken by the PHLS included all reported cases, as well as all cases presented to General Practitioners (GPs) and cases in the community not presented to GPs. This survey was repeated in 2011. Although the ratio of reported to community cases had increased to 1:4.7 this was insufficient to account for the decrease in reported disease incidence. So all available evidence indicates that the controls put voluntarily in place by the industry as a requirement of the Lion Code have successfully reduced the public health risks and the disease. In 2002 the HPA tested 28,000 British eggs and found none contaminated with salmonella.

There are apparently two key factors in the success of this control and prevention scheme. Firstly is the increased biosecurity, with the introduction of strong, easily achieved procedures and processes to reduce horizontal transmission of the bacteria into the flocks. These include the treatment of feedstuffs, the use of biosecurity barriers with foot dips or boot changes, the exclusion of wildlife (including rodents and wild birds), pets and insects and the rigorous cleaning and disinfection of houses between flocks. The second, and arguably most important factor, was the mandatory vaccination of breeder and layer flocks firstly against S. enteritidis and more recently against S. typhimurium.

The role of vaccination

The vaccination of poultry against salmonella started as early as 1989 with the development firstly of an inactivated S. enteritidis PT4 vaccine, which was launched commercially in 1994 initially for use in breeder flocks and then in layers in 1997 and becoming a compulsory part of the Lion Code in 1998.

By 2001 a live oral S. enteritidis vaccine had been launched followed in 2003 by a live oral S. typhimurium vaccine. By 2014 the first dual live vaccine was available in the UK.

Since 2014 the majority of breeder and layer flocks in the UK have been vaccinated by live, rather than inactivated, vaccines. Apart from ease of oral vaccination, live vaccines have the additional advantage of inducing a cellular immune response as well as gut mucosal antibodies, both of which are necessary for fully effective and sustained immune protection.

Upgrade of the Lion Code

During 2014 the Lion Code was revised (Lion Code 7). These revisions include compulsory vaccination with S. typhimurium (except caged flocks under veterinary certification) as well as S. enteritidis and specify increased daily flock inspections. They also specify restrictions on the use of antibiotics (especially fluroquinolones and cephalosporins) in response to current worldwide concerns about the increasing incidence of antibiotic resistant human bacterial infections as a result of the veterinary use of antibiotics in food producing animals.

Conclusions

The evidence is now clear that, at least for this poultry-associated bacterial foodborne intestinal infection, significant public health benefits have been achieved from the successful introduction of a Code of Practice introduced voluntarily and taken up rigorously by the egg industry.

The overall effect was to provide the consumer with confidence in the product. Nevertheless, it took 25 years for egg consumption in the UK to return to the 'pre-Currie' levels.

The same strategic approaches have now been adopted by the poultry meat industry, supported by the Assured Chicken Production Scheme, which uses the Red Tractor logo as a quality mark and today has 2,510 industry members.

This scheme includes the testing of every broiler flock monthly for salmonella, enhanced biosecurity and animal welfare, and total traceability of the life of the bird. The success of the UK strategy for controlling salmonellosis has acted as a model for the rest of Europe.

Since 2000 the EU has introduced a number of regulations aimed at reducing salmonella in breeder, layer and broiler flocks, following similar approaches to those adopted in the UK, with the result that salmonellosis levels are falling throughout Europe.

Now the challenge for the poultry industry, regulators, medics, veterinarians and scientists is to deal as successfully with campylobacter! ■

References are available from the author on request

Fig. 2. Trends in the reporting of incidents of Salmonella enterica in chickens in Great Britain versus laboratory reporting of human S. enterica serovar enteritidis infection, England and Wales, 1985-2011.