COORDINATED APPROACH TO CONTROLLING FOODBORNE ZOONOSES – ACHIEVEMENTS AND FUTURE PROSPECTS

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Food safety is a relative concept and not an inherent biological characteristic of a particular food. We can define safe food as one that does not exceed an acceptable level of risk in relation to microbiological, chemical and nutritional aspects of the product. Decisions on acceptability involve not only science-based ones but also perceptions, opinions and values. Thus where science-based approaches balance risk against benefit and cost, value-based approaches balance risk against dread and outrage perceived by stakeholders especially consumers. This partly explains why microbiological risks vary so much in their acceptable risk along the foodchain. For certain pathogens such as Verocytotoxigenic *Escherichia coli* O157 (VTEC O157) the acceptable level of risk may be as low as zero along most of the foodchain, whereas campyobacter's acceptance level may be higher. Acceptable risk levels for *Salmonella* strains vary depending on factors such as serotype and antimicrobial resistance. However, irrespective of the acceptable risk it is incumbent on all of us including the consumer to limit and reduce as far as is practical the contamination of our foodchain with potentially harmful microorganisms and intoxicants. Our food-supply chains whether international, national or local provide numerous opportunities from farm to fork for the microbiological contamination of food and water for human consumption.

Given the enormous number and variety of potential contamination sources along the food processing chain, it is unrealistic to imagine that all food can be kept free from contamination throughout the process. However, it is now recognised that one key way to enhance food safety is to identify the critical contamination points affecting the safety of the final product. It should then be possible to introduce the most effective measures to minimise or eliminate the possibility of contamination from food production and processing to distribution, preparation and consumption. Advances in the twentieth century such as pasteurisation, refrigeration and more recent improvements in hazard analysis and control along the foodchain have contributed to improvements to the microbiological safety of most foods. Nevertheless, foodborne disease remains a significant cause of morbidity and mortality in Europe and the rest of the developed world. The most recent national surveillance study in England and Wales revealed that one in five people developed infectious intestinal disease each year, and that *Campylobacter* and *Salmonella* were the most common bacterial pathogens isolated (9). In the United States it has been estimated that foodborne diseases may cause up to 76 million illnesses, 325,000 hospitalisations, and 5,000 deaths each year (7). In the same study *Campylobacter*, nontyphoidal *Salmonella* and VTEC accounted for the vast majority of bacterial foodborne disease requiring hospitalisation. *Toxoplasma gondii* and Norwalk-like viruses accounted for the great majority of severe cases of parasitic and viral infections respectively. These two recent studies bear out the generally high estimated national and international human incidence of foodborne pathogens, especially *Salmonella* and *Campylobacter* in most parts of the developed world (Table 1).

Table 1. Estimated 2002 incidence of bacterial foodborne zoonoses Incidence per 100,000 population

	Europe* (a)	**USA(b)**	**Australia(c)**	**Japan(d)**
Salmonellosis	**51**	**15.1**	**39.5**	**5**
Campylobacteriosis	**53**	**13.8**	**112**	**2.5**
VTEC infections	**0.7**	**1.6**	**0.3**	**1.5**
Listeriosis	**0.3**	**0.3**	**0.3**	**ND**
Yersiniosis	**4.0**	**1.0**	**1.5**	**ND**

* Austria, Belgium, Denmark, France, Germany, Ireland, Spain, Sweden, United Kingdom
a) European Commission, 2004 (6), b) Anon, 2002 (1), c) Yohannes et al. (10), d) Anon, 2003 (2)

Taken together this data confirms the continuing importance of food as a source of human illness and, in particular, of foodborne zoonotic diseases arising from the infection of farmed livestock throughout Europe with these microbial pathogens.

Estimates for economic loss covering health costs, lost production and family-related expenses are imprecise due to the paucity and non-standardisation of data and approaches to provide the estimates. However, in England and Wales *Salmonella* cases alone could cost in excess of £100 million each year and in the US in 1996 it has been estimated that *Campylobacter* spp., *Salmonella*, VTEC O157 and *T. gondii* cost the public purse 0.8-5.7; 0.9-3.6; 0.16-0.3 and $3.3 billion respectively (4).

Integrated surveillance systems and molecular epidemiological tools are being used with increasing success to identify the contaminated food vehicles and sources associated with foodborne zoonotic agents and human outbreaks.. For example, *S. enteritidis* in poultry and in particular egg products, *Campylobacter* in poultry meat products, and *E. coli* O157 in ground and sliced beef , contaminated dairy produce and contaminated water sources. Many of these outbreaks and probably a number of sporadic infections can be avoided through correct hygiene procedures in the processing and handling of foods. However, only a co-ordinated farm to fork approach is likely to achieve permanent and significant reductions in foodborne infections in the future. Countries in the European Union operate within the new framework of the 2003 Zoonoses Directive 2003/99/EC (5) part of which is to monitor and control *Salmonella* and other specified foodborne zoonotic agents. The strategy focuses on the poultry breeding and layer sector and has, to a greater or lesser extent, demonstrated that an integrated and co-ordinated approach to controlling *Salmonella* in domestic livestock is feasible and leads to a sustained reduction in human incidences. This is best exemplified by examining the relative effectiveness of the Danish control programmes via the published estimated food sources of human salmonellosis in Denmark in 2002 (Fig. 1)(3).

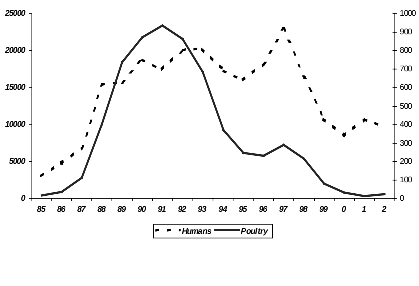
Fig.1. Estimated important food sources of human salmonellosis in Denmark, 1988-2002

Although admitted to be a rather imprecise assessment it clearly shows the dynamics in the changing sources of human salmonellosis over a 14-year cycle. Denmark experienced three waves of human salmonellosis, where the majority of cases were attributed to three different food sources. In the late 1980s broilers were the major food source, whereas in the mid 1990s pork products increased in significance and from the mid 1990s to the end of the century eggs and egg products predominated.

At each of the peaks of human salmonellosis new control programmes focusing on primary production were implemented and resulted in a reduction of human cases attributable to that particular food source (1988 – broilers, 1993 – pork, 1997 – table eggs).

In the UK there has been an association between the decline of laboratory reports of S. Enteritidis in humans and in the reduction of incidents in poultry in the last decade. Undoubtedly, the introduction of vaccination in poultry breeder and layer flocks in 1997 and 1998 has contributed to the sustained reduction of S. Enteritidis in UK poultry. flocks and probably impacted significantly on human cases (Fig. 2)

Figure 2. Salmonella Enteritidis in humans and poultry in UK 1985-2002



This provides clear evidence that intensive and co-ordinated *Salmonella* control programmes in animals can effect a reduction in human salmonellosis from that food source. It also provides sound evidence that controlling salmonella in animals is a very important control point in the entire foodchain and, at least in Denmark, is economically viable for the producers. It is too early to say how many other European countries can apply this approach since type and integration of poultry production varies considerably between countries. Recent reports indicate that a few countries have managed to reduce the prevalence of campylobacter in their broiler flocks but only time will tell us if this impacts on human cases and how economically viable these intensive biosecurity and monitoring programmes prove to be.

Some significant successes in reducing *Salmonella* infections in primary production with real impacts on human cases in many countries, should not detract from other real challenges for the future. *Campylobacter* infections are now the commonest cause of bacterial foodborne infections and in the most recent study in the UK, ranked second in the list of organisms isolated from cases of infective diarrhoeal infections. Human VTEC O157 cases have continued, implicating a variety of contaminated food sources and direct animal to human contact. *Cryptosporidium* either alone or as mixed infections with other foodborne pathogens continues to cause large outbreaks through contamination of water supplies. Increase and emergence of antibiotic resistance and multiply resistant bacterial strains, some of which have arisen from animals and their environment, highlights the immediate requirements for improved surveillance methods and alternative strategies for controlling infections. Potential emergence of new *Salmonella* epidemic strains e.g. multi-resisitant S. Newport in the US and S. Java in parts of continental Europe and continued evolution of VTECs highlights the need for robust early-warning systems and greater understanding of the mechanisms of genetic mutation and adaptation (8).

The farm to fork concept has encouraged closer co-operation between all sectors of the food industry and as stated above achieved some considerable successes in reducing *Salmonella* in livestock. However, it is likely that the most cost effective way within limited resources in targeting longer term strategies to control foodborne zoonotic infections in animals, is to focus on emerging trends in human infections caused by the major foodborne zoonotic pathogens, since most of these organisms are asymptomatic in animals. Thus integrated research and surveillance of animal and human foodborne zoonotic infections is crucial to future strategies. For example, rapid dissemination of changing trends between veterinary and medical sectors to improve response to emerging pathogens, changes in antimicrobial resistance patterns, co-ordination of surveillance systems that can accurately identify results of intervention methods implemented along the food chain and co-ordination and integration of research objectives. Thus the original farm to fork approach often ignored the key component along the food chain which should help to formulate future strategies i.e. seamless and co-ordinated foodchain strategy. It is also now recognised that many of the most effective solutions will not be pathogen specific but focus on factors common to many different organisms in the foodchain. There are a number of recent initiatives that seek to address coordination at the national, European and global arenas and some examples are described below.

National

Close co-operation between veterinary and public health sectors is vital for the early identification of new and emerging zoonoses and to monitor and act upon changing trends in the epidemiology of foodborne pathogens. For example, in GB the Health Protection Agency and the Veterinary Laboratories Agency have initiated a programme for the harmonisation of laboratory methods for the detection and identification of a range of pathogens such as salmonella, campylobacter, VTECs including O157 and O26 and measurement of antimicrobial resistance. This will facilitate improved comparison of surveillance and incident data along the foodchain and will be used to compare temporal trends. Likewise standard approaches to the molecular typing of these organisms have already improved the management of outbreak investigations. For example, a recent local outbreak of S. Java in cattle in the England was enhanced by the rapid determination of the clonal type that was found to be unrelated to the European epidemic strain. In parallel, increased joint reporting of pathogens and antimicrobial resistance patterns from veterinary, food and medical sources increases the awareness of these organisms in terms of public health importance – initiatives that have been long established in some other countries e.g. Denmark and Sweden.

European

Following a series of food scares in the 1990s (eg BSE, dioxins…) which undermined consumer confidence in the safety of the food chain, the European Union concluded that it needed to establish a new scientific body charged with providing independent and objective advice on food safety issues associated with the food chain. The result was the European Food Safety Authority (EFSA). Established in 2002 and soon to be moving to a permanent site in Italy, EFSA provides independent scientific advice on all matters linked to food and feed safety - including animal health and welfare and plant protection - and provides scientific advice on nutrition in relation to Community legislation. The Authority communicates to the public in an open and transparent way on all matters within its remit. EFSA's risk assessments provide risk managers in Europe and elsewhere with a sound scientific basis for defining policy driven legislative or regulatory measures required to ensure a high level of consumer protection with regards to food safety. EFSA is now dealing principally with requests for risk assessments from the European Commission and plans to take on a wider brief from other European institutions in the near future.

EC COST Action funding is a very flexible and efficient means of linking research and surveillance activities across Europe. COST 920 – *Foodborne zoonoses : a co-ordinated foodchain approach* is an ongoing action that seeks to co-ordinate information along the foodchain to facilitate control of foodborne pathogens in 22 participating European countries. In particular, it draws together colleagues working along the foodchain to consider and present their most recent research and surveillance information on :

- comparability of surveillance data
- proactive approaches to new and emerging zoonoses
- integration of risk assessment into foodchain activities
- in-depth understanding of the foodchain hazards

The programme comprises four integrated working groups :

1. isolation, identification and typing methods
2. new and emerging foodborne pathogens
3. quantitative foodchain risk assessment
4. survivial of zoonotic pathogens along the foodchain

Outputs and proceedings of the various activities and meetings can be located at www.Cost920.com .

Complementary to the co-operative activities in COST 920 is Med-Vet-Net (MVN) a new European network of excellence for the integration of veterinary, medical and food sciences in the the field of food safety (15 partners in 10 countries). The objective of MVN is to improve research on the prevention and control of zoonoses while taking into account the public health concerns of consumers and other stakeholders throughout the foodchain and is due to begin in the latter half of 2004. This initiative has the scope to fund not only targeted research activities but the dissemination of results at meetings and will work closely with COST 920. Further information can be found at www.medvetnet.org/

Global

The World Health Organization (WHO) recognises the importance of foodborne diseases worldwide and has estimated that in less developed countries approximately 1.8 million people die, most of whom are children, from food and waterborne diarrhoeal diseases. A significant proportion of these are caused by zoonotic organisms originating from animals or their environment in the primary production sector of the foodchain. In 2002, the WHO published their Global Strategy for Food Safety with the goal to reduce the health and social burden of foodborne disease. Key approaches include the improvement of current surveillance of foodborne diseases through an interdisciplinary approach including all sectors dealing with foodborne diseases and food safety in both the health and agriculture sectors. Effective integrated surveillance is vital for the formulation of national and global strategies to reduce food-related risks. Improved microbiological risk assessment and risk communication are also very important by a) providing a tool to set priorities for future interventions that will improve public health through the reduction of microbiological hazards along the entire foodchain and b) developing methods to effectively communicate the risks to stakeholders, including consumers, in a clear and understandable manner.

There are some good examples of how this strategy is being applied globally in a practical way to control foodborne diseases. Global Salm-Surv (GSS) is a global network of laboratories and individuals involved in surveillance, isolation, identification and antimicrobial resistance testing of *Salmonella*. It is targeted to microbiologists and epidemiologists who work in public health, veterinary services, food-related services and environmental health. Its aim is to strengthen the capacities and expertise of WHO member states in the surveillance and control of *Salmonella* infections and to contribute to the effort of reducing antimicrobial resistance in foodborne pathogens. It is being extended to other major pathogens including *Campylobacter*. Information can be found at www.who.int/salmsurv/en/ .Enter-net is a European funded global surveillance network for the enteric infections Salmonella and VTEC O157 and concentrates on the harmonisation of methods and maintenance of a timely international database. Considerable achievements have been made in the early identification of global outbreaks particularly *Salmonella* that have lead to effective public health measures being applied to limit the impact of the outbreak by, for example, identifying the contaminated source and removing it from the foodchain. This has proved to be a highly effective network by targeting and identifying potential human international outbreaks. It is hoped that it can be enhanced further by including animal data that will contribute to the identification of animal sources involved in future outbreaks and hence support the sustained control of foodborne pathogens by targeting primary production as well as contaminated food and food products. Details can be found at www.hpa.org.uk/hpa/inter/enter-net .PulseNet USA and PulseNet Canada are national networks of public health and federal food regulatory agency laboratories in North America who routinely perform standardized molecular subtyping of foodborne disease-causing bacteria and then share DNA 'fingerprints' electronically in real-time via Internet. The aim is to :

- detect foodborne disease clusters
- facilitate early indentification of common source outbreaks
- assist epidemiologists in investigating outbreaks
- assist in rapidly identifying the source of outbreaks

The following examples provide clear evidence of the contribution of PulseNet in recent foodborne outbreaks :

- 1997 : 16 VTEC O157 infections linked by Pulse Field Gel Electrophoresis (PFGE) in two states, 25 million pounds of ground beef recalled.
- 1998 : 486 *Shigella* infections in 3 states in Canada traced to parsley imported from Mexico.
- 1999 : Salmonella infections in 22 states traced to mangoes imported from Brazil.
- 2000 : Salmonella infections in 8 states, linked to orange juice produced using new, whole fruit pasteurization process.
- 2001 : Multistate *Listeria* outbreak linked to deli turkey meat.

The success of PulseNet in North America has provided the impetus for a similar PulseNet Europe network to be considered that proposes to harmonize with PulseNet in North America but to enhance the sharing of molecular data between the public health, food and agriculture sectors. This is an important initiative that attempts not only to enhance the current surveillance of human foodborne pathogens but to extend the network to the important primary production sector. If successful it will not only impact on the control of foodborne outbreaks in Europe but provide valuable new information on the sources and spread of potentially epidemic foodborne zoonotic pathogens in farmed livestock that will enhance active veterinary surveillance and help to sustain reductions in foodborne pathogens along the entire foodchain.

Summary

By the beginning of the twenty first century foodborne zoonoses have become the major cause of infectious intestinal disease in humans in many developed countries, replacing infections classically associated with poorly developed sanitary and housing conditions such as cholera, typhoid and dysentery.

The integration and globalisation of food production along the foodchain has facilitated the rapid spread of infections such as *Salmonella* and *Campylobacter*. The most notable example being the *S.* Enteritidis pandemic of the 1980s and 1990s. However, other factors including the emergence of new foodborne pathogens have also had a considerable impact. In particular, the emergence of VTEC O157 and spread of multi-resisitant *Salmonella* strains through the likely acquisition of relevant genetic material by an otherwise commensal or antimicrobial sensitive bacterium. These are powerful examples of the potential of new and emerging pathogens spreading rapidly through animal and human populations.

Paradoxically, the integration and globalisation of food production, also offers improved opportunities for the control of many of these pathogens.

Considerable progress has been made in the coordination of activities along the foodchain, and this paper has cited excellent examples of national, international and global sharing of data and intelligence that are having a practical impact on controlling foodborne pathogens in animals, foods and humans. The ability to rapidly share surveillance data is crucial in the battle to improve the quality of our food. The development of horizontal (geographical) and vertical (foodchain) data networks is very much in its infancy and is becoming a significant challenge, but much greater integration is vital if we are to contunue to build on recent successes. Furthermore, food safety risk analysis will need to combine robust mathematical models with secure quantitative microbiological data to reduce the level of uncertainty in many of the current risk assessments. This will facilitate accurate identification of those points along the foodchain that contribute most cost effectively to the control and spread of the organisms. As a result, improved cost effective control programmes should be developed, thus offering new opportunities to countries in which hitherto control methods have been considered too expensive. The lesson of the last thirty years has also clearly indicated the importance of surveillance in any control programme, not only to identify emerging problems, but to demonstrate effectiveness of the programmes themselves.

References

1. Anon (2002). Preliminary FoodNet data on the incidence of foodborne illnesses – selected sites, United States, 2001. MMWR 51 (15), 325-329.
2. Anon (2003). Salmonellosis in Japan as of June 2003. IASR 24, 179-180.
3. Anon (2003). Annual Report on Zoonoses in Denmark 2002, Ministry of Food, Agriculture and Fisherises.
4. Doores, S. (1999). Food Safety – Current status and future needs. A report from the American Academy of Microbiology, Washington, D.C. USA.
5. European Commission (2003). Council Directive 2003/99/EC of 17 November 2003 on the monitoring of zoonoses and zoonotic agents, amending Council Decision 90/424/EEC and repealing Council Directive 92/117/EEC. Off. J. Eur. Communities, No L325/38 of 12.12.2003, 1-13.
6. European Commission (2004). Trends and sources of zoonotic agents in animals, feedingstuffs, food and man in the European Union and Norway in 2002. European Commission, Directorate D – Food Safety : production and distribution chain. European Commission SANCO/29/2004 Part 1 294pp.
7. Mead, P.S., Slutsker, L., Dietz, V. et al. (1999). Food-related illness and death in the United States. EID 5, 607-625.
8. Thorns, C.J. (2000). Bacterial food-borne zoonoses. Rev.sci.tech.Off.int.Epiz., 19(1), 226-239.
9. Wheeler J.G., Sethi D., Cowden J.M., Wall P.G., Rodriguez L.C., Tompkins D.S., et al. (1999). Study of infectious intestinal disease in England: rates in the comunity, presenting to general practice, and reported to national surveillance. *BMJ*, 318, 1046-1050.
10. Yohannes, K., Roche, P., Blumer, C. et al (2004). Australia's notifiable diseases status, 2002. Annual report of the notifiable diseases surveillance system. CDI, 28 (1), 1-18.