

Economic aspects of food-borne outbreaks and their control

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This paper begins with a discussion of the definition of an outbreak. It considers the portion of outbreaks in the general pattern of food-borne infectious disease. The methods used to identify outbreaks are described and the importance of the potential benefits and the economic impact of outbreak recognition and control and are discussed. The paper concludes by illustrating the economic impact of intervention using three infectious diseases botulism, *Salmonella* and *Escherichia coli* O157 as case studies of outbreaks.

What is an outbreak? An outbreak is said to occur when two or more cases of an infectious illness are linked by epidemiological, clinical or microbiological evidence. A food-borne outbreak is one caused or thought to be caused by food or water. Food-borne infections have been rising steeply over the past decades and, although better identification of organisms and possibly better reporting has contributed to this trend, there does appear to be a growing problem. Concern about food-borne infection was heightened in the UK in the late 1980s following the identification of *Salmonella enteritidis* in eggs. This led to the setting up of the Committee on Microbiological Safety of Food (Richmond Committee)¹ and to the Study of Infectious Intestinal Disease in England,² a microbiological, epidemiological and economic assessment of disease. Reports of infectious intestinal disease have continued to rise. *Campylobacter* spp. and *Salmonella* spp. account for a large portion of cases but more virulent forms of infections such as *Escherichia coli* O157:H7 have emerged as important risks. However, in 1997 and 1998, there was a fall in reports of *S. enteritidis* and *Salmonella typhimurium* outbreaks. Much of this disease burden is likely to be food or water borne.

It has been estimated that the cost of intestinal infections for England is £750 million². The burden of infection is felt by those infected, those whom they might infect and those who care for them either informally at home or as part of the formal health services. Preventive policies for

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food-borne infectious intestinal disease need to address all points along the food-chain, particularly critical points that have been found to be risky and have hazardous consequences. This may be part of a formal hazard analysis and critical control point (HACCP) system. HACCP identifies steps in the process that are critical and assesses the consequences to health that may arise if mistakes occur³. If possible, strategies to reduce hazards should be in place. This endeavour involves commercial producers, farmers and market gardeners and private individuals who garden or who collect food-stuffs for consumption, manufacturers and purveyors of food and those who prepare food for consumption. If at any point in the system prevention fails an outbreak may occur.

Notification of disease

There are three systems of notification of infectious disease in the England and Wales. The first is based on clinical reports. Every doctor in clinical practice has a statutory duty to report certain infectious diseases and food poisoning to the consultant in communicable disease control (CCDC). The second is the national surveillance scheme of laboratory-confirmed infections reported by public health and NHS laboratories to the Centre for Communicable Disease Surveillance (CDSC) at the Public Health Laboratory Service (PHLS). The third is a national surveillance system for general outbreaks that relies upon reports of outbreaks by the CsCDC to the CDSC at the PHLS. Food poisoning is also reported to CDSC at the PHLS by environmental health departments of local authorities. Reported cases reflect only a small portion of illnesses experienced in the community.

The proportion of diseases identified using community surveys and those identified using notification systems of infectious intestinal disease vary by infectious group. The study of Infectious Intestinal Disease in England² found that cases in the community were identified by notification systems more frequently for salmonellas than for viruses, particularly small round structured viruses (SRSV). One in 3 cases of salmonellosis and 1 in 7 campylobacteriosis cases were reported compared to 1 in 1567 for SRSV, possibly because of the relatively short duration of illness associated with SRSV. For each case visiting the GP, there were approximately 6 cases in the community.

These findings support the view that food-borne infections are under-reported. Unfortunately, because there was no easy way of collecting suspect food products for testing from the cases or controls recruited to the Infectious Intestinal Disease Study, it was not possible to estimate the proportion of cases that were food-borne from that study.

In the US, it has been estimated that between 6.5 million and 33 million illnesses and up to 900 deaths occur each year from food-borne microbes (namely, bacteria, parasites, viruses and fungi)⁴. The risk of fatality from a food-borne event for the population has been estimated in the US to be 1/29,000⁵.

Identification of outbreaks

Identification of an outbreak might occur in a number of ways. Possibly most outbreaks are discovered by cases reported to CsCDC by alert individuals – general practitioners, hospital doctors and microbiologists. A good example of a rapid response was the one that led to the identification of an outbreak of *E. coli* O157 in Lothian in 1994⁶. In this outbreak, a hospital doctor, a GP and a microbiologist contacted the CCDC within hours of each other to report that they had seen suspicious cases or, in the case of the microbiologist, had identified the organism. National surveillance is frequently the only way of detecting an outbreak where cases are spread widely across the country. An example of this type of identification was a *Salmonella agona* outbreak identified in North London, and traced to other areas in Europe, Canada and the US and tracked back to a manufacturer in Israel⁷. Increasingly, given the growth of electronic data bases and linked reporting, scanning for higher than expected reports may prove useful in the identification of outbreaks. A surveillance system, linked to a public health network that can investigate and implement control strategies, can contribute directly to the interruption of an epidemic and to the reduction in the risk of future epidemics⁸.

Outbreaks make up only a small proportion of cases of infections notified to the public health laboratory service. The number of outbreaks identified varies by organism for a number of reasons: length of illness, the likelihood of tests being taken and the microbiological sensitivity and specificity of the testing. The identification of outbreaks often depends upon the ability to link cases microbiologically. The ability to do this varies by organism. Sub-types of salmonella can be accurately identified. Such identification facilitates investigations. Identified outbreaks of salmonella make up about 10% of reported cases. A similar percentage of *E. coli* O157 cases are identified as outbreaks possibly because of the seriousness of the illness and the availability of highly specific tests that make it easy to match cases and associated food or environmental samples. Only 0.2% of *Campylobacter* cases are linked with outbreaks⁹. This is largely because it has proved impossible to sub-type campylobacters isolated in clinical practice, from foods and from the environment. A number of campylobacter infections may well be part of undetected outbreaks.

Benefits to identification of outbreaks

Outbreaks are costly, attract media attention and cause alarm. The costs of not identifying an outbreak, however, may be even more substantial. The main benefit from outbreak recognition is to prevent further spread. The economic benefits that result from an intervention will vary by outbreak. The net benefits depend on the costs of the investigation compared to the benefits accruing from interrupting the outbreak.

Identifying and controlling an outbreak may reduce the number of cases infected, improve clinical care and provide opportunities for prevention of other outbreaks thus reducing the long-term and short-term morbidity and costs. If the outbreak arose from a single source and was self-limiting, no primary cases may be avoided but the number of secondary cases may be reduced and lessons may be learnt that may affect future practice and prevent recurrences. An example of this type of outbreak often recounted is that of the wedding breakfast at which chickens, cooked the previous day and packed in the boxes in which they were delivered when raw, infected all the wedding guests with salmonella. No doubt the caterer and the wedding party learnt from this. Single source outbreaks may contribute more to prevention of disease if the contaminated product can be removed rapidly from the shelves. This happens quite frequently. Good examples of interventions of this kind include an outbreak of botulism traced to contaminated hazelnut conserve used to flavour yoghurt. This was removed from the food chain¹⁰. Another was an identification of an outbreak of *Salmonella napoli* in chocolate bars¹¹. This resulted in 80% of a consignment being withdrawn from sale. These examples are discussed as case studies below.

Often the outbreak is caused by a continuing source that would cause infection indefinitely. The outbreak of *S. agona* caused by a fault in the production process is an example of this^{7,12}. Outbreaks can also arise from a recurring source perhaps in a private water supply. These can be modified by interventions and advice, e.g. advice about boiling water during outbreaks due to *Cryptosporidium*¹³.

The lessons learnt from an outbreak may lead to improvements in practice or regulation that can prevent further epidemics or outbreaks occurring. The improvements might modify or remove the source of infection, e.g. facilities for hand-washing at farm centres or children's zoos may reduce the likelihood of infections due to *Campylobacter* and *E. coli* O157:H7¹⁴ or recommendations or advice about preparation and storage procedures – pasteurisation processes with relation to *Listeria*¹⁵ or to changes in production procedures – *S. agona*⁷ and botulism outbreaks¹⁰.

Identification of the infective agent can modify treatment and so reduce morbidity and mortality. The identification of the infective agent could reduce the likelihood of misdiagnosis and unnecessary surgical

interventions in cases with acute abdominal pain, such as that associated with campylobacter and *E. coli* O157. Rapid identification of infections such as *Cryptosporidium* may provide important clinical information for the management of those with reduced immunity.

Advice to infected individuals, those who look after them and to institutions who employ them or look after them is very important in containing an outbreak and avoiding secondary spread. This can result in: (i) isolation of patients to reduce the spread of infection, *e.g.* isolation in cases of listeriosis in mother and baby units; (ii) limiting person-to-person spread, *e.g.* exclusion from work or school, advice to formal and informal carers; and (iii) suggesting institutional interventions, *e.g.* ward closures, cleaning to reduce contamination of air or water.

Information, and advice to the public and industry that is accurate and timely can reduce public and professional concern associated with scare stories and outbreaks, *e.g.* handling of the panic about the perceived threat of 'super bug' and the 'flesh-eating bacteria'. Credible management of the potential threat can allow adjustments and changes to be made to behaviour or manufacturing practice, *e.g.* an outbreak of salmonella in kebanos sausages was handled promptly by taking products off the shelves. Subsequently, the product was manufactured using a pasteurisation process so limiting further outbreaks from that source¹⁶.

High profile outbreaks can provide a catalyst for change. Arguably the Lanarkshire outbreak of *E. coli* O157 provided a catalyst for changes that led not only to changes in regulations relating to retail practices but added to the political pressure for a food standards agency¹⁷.

An outbreak that goes unrecognised will not recoup the benefits outlined above.

Economic aspects

Evaluating infectious disease control consists of evaluating an absence – the avoidance of any infection potentially frees up resources that can then be used for other purposes. A full economic appraisal of an outbreak would seek to cost and analyse the intricate web of activities and value their contribution. Evaluations, typically in the form of cost of illness studies, provide minimum estimates of the value to society of the avoidance of disease. Some infections have a significance in the popular imagination, cultural and value systems that imply that society would be willing to pay more than the mere resource costs of the illness in order to avoid them. Policy making takes place in the context of such culturally determined fears and beliefs. Estimations of the costs of illness, together with descriptions of the disease characteristics, could provide information that could form a basis for using a willingness to pay approach to

estimating benefits. Such estimates of the value society places on avoiding infection would allow an economic evaluation to take the form of a full cost-benefit study that would indicate the rate of return to intervening in an outbreak.

As willingness to pay studies are difficult to undertake, the most useful approach at present appears to involve assessing the opportunity costs of the resources forgone because of the infection. A bed used by someone suffering unnecessarily from an infection, given the pressure on resources in the health sector, deprives someone else of treatment. Intervention may reduce illness and so save resources of the public health laboratory services, the resources of the health care sector, including hospital, GP and community services, and the time and resources of people infected and those who care for them¹⁸.

Few studies have offered a comprehensive account of the implications of an outbreak. Attempts were made to cost the intervention including costs to the patient and the family, the NHS, and public health departments were made in the costs of *S. napoli* outbreak¹¹, the national study of salmonellosis¹⁹ and the *E. coli* O157 study⁶. Few estimate the costs of the intervention, few trace out the costs beyond the health sector and few project the costs to encompass the long-term sequelae of the illness²⁰.

Studies of outbreaks usually allow a more comprehensive range of costs to be included. Each outbreak, however, is different and the estimates may not be generalisable. On the other hand, estimates using epidemiological surveys will usually exclude the costs of investigating cases and the costs to third parties resulting from the illness². Estimates

Table 1 Estimates of the costs of intestinal infectious disease in England

Cost category	Costs per case (£) All intestinal infectious disease	Costs per case (£) Salmonella
Those visiting a GP		
National Health Service		
GP costs	44 8	47 8
Hospital costs	17 6	84 0
Costs to cases and carers		
Direct costs	15 5	34 3
Indirect costs (including time off work)	174 9	440 3
Total	253 8	606 5
Costs of community cases who did not see a GP		
Costs to cases and carers		
Direct costs	3 9	3 8
Indirect costs (including time off work)	30 6	40 0
Total*	34 5	43 8

Adapted from the *Report of Infectious Intestinal Disease in England*²

*Subject to rounding errors.

based on reported cases will represent a different cost profile from those based on a community survey². Some studies have concentrated only on hospital costs of illness²¹. These cases represent the most severe and most expensive cases. Those who see a GP will cost more than those who do not and those who do not have been found to be less severely ill². Table 1 indicates the distribution of costs of infectious intestinal disease in England². It is clear that the costs of all intestinal infectious disease, that includes many short-term virus infections, is much lower than the costs of cases with salmonella.

It is possible to estimate the contribution of early detection and control both from self-limiting and potentially continuous sources.

Case studies

Case studies will be used to illustrate the impact of interventions that have taken place.

Botulism

Rapid and successful intervention prevented illness and the high costs associated with an outbreak of botulism in hazelnut flavoured yoghurt. The intervention to remove the source of infection reduced the outbreak by at least one half, probably more, as, in addition to the removal of yoghurt from the shelves, a can of infected hazelnut conserve that would have been used to produce more yoghurt was taken out of the food-chain. The process of producing hazelnut conserve was also changed limiting the likelihood of recurrence from this source. The rapid identification of the source of infection was of paramount importance in this outbreak. Successful identification can save in the order of £22,000 per case to the health sector alone. The high mortality and high health care costs make this the second most expensive infectious disease in the acute phase of illness. The intervention was likely to have saved over £606,000 to the health sector and £4–10 million in total, using the lowest value of lives lost⁸. The cost of the intervention was largely the cost of the time of the consultant investigating the outbreak and the costs of testing the cases and food samples. The cost of the investigation was unlikely to have been more than £6000 including the removed products from the shelves.

Salmonellosis

A national outbreak of salmonellosis due to chocolate contaminated with *S. napoli* occurred. As a result of the detection and control of this

outbreak 80% of a consignment of chocolate from Italy was withdrawn from sale and the outbreak with its attendant cost limited¹¹. At 1995 prices, the value of this intervention would have been £8.7 million in health care cost, £4.8 million in public health costs, and £13.5 million in costs to patients and families. The cost of the intervention yielded a 3.5-fold rate of return. The measured benefit related to the UK but the intervention no doubt prevented many cases in continental Europe.

A more recent intervention to prevent salmonellosis, *S. agona*, similarly interrupted an outbreak. The savings were primarily in Israel where some 2000 cases were avoided – cost savings in UK prices of some £600,000 to the health care sector alone and some £10–16 million in total. The intervention also may have led to changes in production methods and so reduced the likelihood of imports from this source causing problems in the future^{7,12}.

E. coli O157

An outbreak of *E. coli* O157:H7 in Lothian in 1994⁶ was brought under control in 36 hours by the timely intervention of those involved and the rapid identification of the source. The cost of the outbreak was very large. The hospital costs associated with treating 71 cases during the acute phase and the subsequent 12 months was £600,000. Some cases were in hospital for over 6 months. Two cases left hospital on dialysis and one has since had a kidney transplant. Had the intervention not occurred to remove the milk supplies ready for distribution from the food-chain, it is likely that more cases would have been infected adding to the costs and suffering of those affected. The pay off to the intervention was thus likely to have been high. However, this outbreak also points to the importance of primary prevention in organisms of such high pathogenicity¹⁷.

Conclusions

It is unlikely that we can reduce food-borne infections entirely. We could, however, reduce them by using adequate control procedures. The adoption of well designed sensitive system of hazard and critical control points (HACCP)³ to stages of food production could limit hazards and risks of infection along the food-chain¹⁷. When primary prevention fails, then rapid detection of outbreaks, intelligent investigation to locate the source and controls to limit the spread are vitally important and investment in this activity is likely to have a high pay off both in the short and long-term.

The food-borne outbreak studies described indicate the potential benefits that arise from early recognition and control of outbreaks. Good

surveillance systems to identify outbreaks are essential. Surveillance costs have not been estimated as they are complex and embedded in clinical and public health medicine. They are, however, likely to be small compared to the enormous costs of infection. The pay off to investment in outbreak detection, investigation and control is many fold.

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