Epidem. Inf. (1988), **101**, 115–122
Printed in Great Britain

Poultry-borne salmonellosis in Scotland

BY W. J. REILLY,
Communicable Diseases (Scotland) Unit, Ruchill Hospital, Glasgow G20 9NB
G. I. FORBES,
Scottish Home and Health Department, Edinburgh
J. C. M. SHARP, S. I. OBOEGBULEM, P. W. COLLIER
Communicable Diseases (Scotland) Unit
AND G. M. PATERSON
Department of Agriculture and Fisheries for Scotland, Glasgow

(*Accepted 8 March 1988*)

SUMMARY

Between 1980–5, 224 outbreaks of salmonellosis associated with poultry-meat were reported in Scotland. In total 2245 persons were affected, 12 of whom died. Twenty-one salmonella serotypes were identified from those affected, while 33 serotypes were isolated from poultry during routine monitoring and disease investigation. Existing measures to prevent the spread of salmonellae within poultry flocks and processing plants are failing. It is suggested that irradiation of poultry-meat may be the only effective method of reducing the public health problem of poultry-borne salmonellosis.

INTRODUCTION

Prior to 1983 milk was the most important food vehicle causing salmonella outbreaks in Scotland, but with the introduction of compulsory heat treatment of cows' milk that year (Sharp, Paterson & Barrett, 1985), poultry-meat (chicken and turkey) has assumed the primary position (Reilly *et al.* 1986).

Broiler chicken production in the United Kingdom only began in 1953 and by 1976 was already producing almost 400 million birds annually (Biggs, 1978). Poultry rearing units have become very intensive with high stocking densities, while modern processing plants may have throughputs of 10000 birds per hour. Thus there is a considerable potential for cross-infection in the live bird and cross-contamination of the end product. The increasing practice of selling chicken portions, raw and cooked, also permits further opportunities for cross-contamination. A direct result of these developments is that although salmonellosis is a minimal poultry health problem, many poultry products are contaminated with salmonellas (Gilbert, 1983) with consequent risk to human health.

This paper examines the available epidemiological data in Scotland during the period 1980–5 and suggests measures which are necessary to control poultry-borne salmonellosis.

MATERIALS AND METHODS

Epidemiological information on episodes of food-borne infection in Scotland was obtained by the district environmental health officer or community health nurse during visits to affected households, following notification by the family doctor or by the laboratory. The clinical and epidemiological history obtained was recorded on standardized investigation and outbreak summary forms and collated at the Communicable Diseases (Scotland) Unit as part of a national surveillance programme. Data relating to outbreaks were analysed by the Information and Statistics Division of the Scottish Health Service, Edinburgh, the results of which were published annually (Collier *et al.* 1985).

An outbreak was accepted as having been poultry-borne where (*a*) the same serotype/phage type had been isolated from persons affected and from available food samples ('left-overs' or other birds from the same consignment within the kitchen); or (*b*) where there was a history of poultry having been consumed and/or prepared within the same kitchen premises 2–3 days prior to onset of illness, supported by the isolation, from affected persons, of an organism known concurrently to be associated with poultry.

Serotyping and phage-typing identification of isolates were undertaken at the Scottish Salmonella Reference Laboratory, Stobhill Hospital, Glasgow and at the Division of Enteric Pathogens, Public Health Laboratory Service, London.

RESULTS

Between 1980 and 1985 there were reported 224 outbreaks of poultry-meat associated salmonellosis affecting 2245 persons, of whom 12 died (Table 1). In 215 of these outbreaks epidemiological evidence implicated poultry-meat, and in 9 salmonella organisms of the same sero/phage type were also isolated from the incriminated poultry product. Poultry-meat accounted for 20% of all salmonella food-borne outbreaks and 35% of persons involved (Fig. 1a), for over 50% of outbreaks where a food vehicle was identified (Fig. 1b), and for almost 70% of persons affected in the 2-year period 1984–5 following the introduction of compulsory heat treatment of milk in 1983 (Fig. 1c).

One hundred and sixty-two (72%) outbreaks affecting 440 (20%) persons occurred in single households, while 62 (28%) affecting 1805 (80%) persons occurred as general community outbreaks.

There was an increase in incidence of outbreaks during the summer months of June, July and August with a smaller secondary peak during December, January and February.

A total of 21 salmonella serotypes was isolated, the most frequent of which were *Salmonella typhimurium*, *S. virchow*, *S. enteritidis*, *S. stanley* and *S. saint-paul* (Table 2). Twenty-five phage types of *S. typhimurium* were identified including, in order of frequency, types 110, 10, 49, 12 and 170 (Table 3). The most commonly identified phage type of *S. enteritidis* was type 8. More than one serotype or phage type was isolated from persons affected in 15 outbreaks. In one incident in 1983, *S. binza*, *S. typhimurium* type 110 and *S. virchow* were recovered in various

Table 1. *Poultry-meat-borne salmonellosis in Scotland, 1980–5*

	1980	1981	1982	1983	1984	1985	Total
Outbreaks	31	44	40	50	40	19	224
Persons affected	365	229	380	384	378	509	2245
Deaths	1	4	—	3	—	4	12

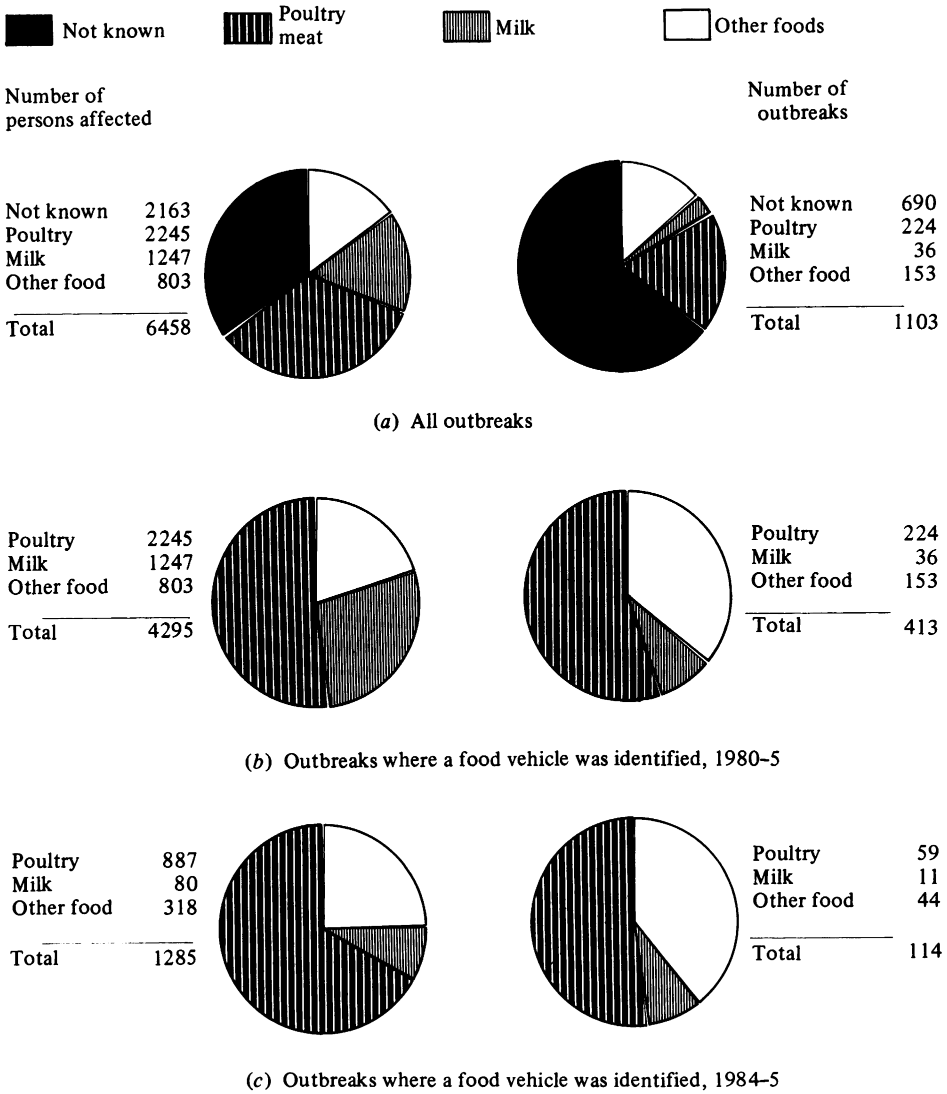

Fig. 1. Salmonella food-borne infection, Scotland, 1980–5.

combinations from those affected, which serotypes were currently prevalent in the poultry flocks of the producer concerned.

All isolations of salmonellas from humans, animals and birds are routinely recorded as part of continuing surveillance in Scotland (Tables 2 and 3). Many of the isolations from poultry were made during routine monitoring or investigations

Table 2. *Ranking order of salmonella serotypes isolated during 1980–5*

Serotype	Ranking order: Poultry-meat-borne outbreaks	Poultry and poultry-meat	Zoonoses order*	Humans†
S. typhimurium	1	1	1	1
S. virchow	2	2	3	3
S. enteritidis	3	6	9	2
S. stanley	4	10	7	6
S. saint-paul	5	15	—	4
S. hadar	6	28	11	9
S. bredeney	7	7	14	11
S. infantis	7	4	4	8
S. heidelberg	9	19	14	5
S. montevideo	9	16	17	12
S. newport	9	9	4	10
No. of different serotypes identified	21	33	29	122

* Incidents reported in Scotland under the Zoonoses Order involving fowls and turkeys.

† Data relating to all human isolates reported to the Communicable Diseases (Scotland) Unit.

Table 3. *Ranking order of* S. typhimurium *phage types isolated in Scotland during 1980–5*

Phage type	Ranking order: Poultry-meat-borne outbreaks	Poultry and poultry-meat	Humans	Cattle	Sheep	Pigs
110	1	1	1	5	3	2
10	2	4	2	7	7	—
49	3	2	4	4	13	—
12	4	7	3	6	1	—
170	5	—	6	11	8	—
204	—	13	5	3	4	—
204a	—	17	7	2	5	—
204c	—	—	8	1	2	1
No. of different phage types identified	25	23	85	36	19	5

of other disease conditions, whereas those from man and other animals followed investigation into clinical salmonellosis. The Zoonoses Order, 1975 requires the notification of all isolations of salmonellas from specific animals and birds and the findings are published annually (Bell & Wray, 1985). Between 1980–5, 29 serotypes were notified in Scotland from fowl and turkeys (Table 2). Phage types of *S. typhimurium* are not recorded.

DISCUSSION

In the United Kingdom the poultry industry has probably expanded faster than any other livestock enterprise. Growth began in 1953 following the end of feedstuffs rationing and in 1985 alone, 428 million broilers were slaughtered (Anon, 1987).

The industry has become very intensive such that birds are reared in large numbers (> 20000 in a single building) and may be slaughtered at a rate of 10000/hour. Control measures adopted by producers include clean egg production, egg fumigation, slaughter of infected breeding flocks and improving hygiene standards in slaughter plants. Nevertheless, cross-infection and cross-contamination still occur and consequently a high proportion of poultry carcases carry salmonellas (Gilbert, 1983). Routine monitoring of frozen poultry-meat in a hospital kitchen in Scotland, for example, following an outbreak in 1983 revealed 7 serotypes, *S. binza*, *S. braenderup*, *S. bredeney*, *S. montevideo*, *S. newport*, *S. schwarzengrund* and *S. typhimurium* from four producers over a 6-week period (T. Jackson, personal communication). The fact that such contaminated food is the major source of food-borne salmonellosis is demonstrated in Tables 2 and 3, which show the similarity between serotypes and phage types of *S. typhimurium* isolated from poultry (and poultry-meat) and those from outbreaks.

The differences observed in serotypes identified in the outbreaks and from poultry can be related to several factors. Not all poultry-meat consumed in Scotland is produced in Scotland. For example, both *S. hadar* and *S. montevideo* which featured in outbreaks, were rarely isolated from Scottish poultry although these organisms were both prevalent elsewhere in the United Kingdom (Bell & Wray, 1985). Conversely *S. worthington* and *S. livingstone* although not commonly causing outbreaks, were isolated from poultry, but in exceptional circumstances; most of the *S. livingstone* isolates were made during 1985 and were associated with one particular company among whose stock this organism was widespread. It would appear from the low incidence of infection reported in humans that this particular serotype was of low virulence in man, although it is worth noting that there were subsequently 28 isolations from humans recorded in 1986 compared with a total of 33 for 1980–5.

Similar explanations account for the differences in phage types isolated from outbreaks and poultry, although the predominant position of types 110, 10, 12 and 49 is clear and contrasts with the lesser importance of these types in other animal species (Table 3).

There have been considerable changes in eating habits in recent years. 'Fast food' outlets have expanded in number, as have other catering establishments. The sale of pre-cooked poultry-meat (whole or portions) is common. Economic pressures on the catering industry may encourage the development of unsatisfactory kitchen practices which allow cross-contamination to occur, while the development of a frozen-food chain has allowed widespread distribution (both in time and geography) of a potentially contaminated product. In consequence the final consumer may be presented with a food contaminated with salmonellas or other pathogenic organisms.

In many outbreaks it may not be possible to identify with any degree of certainty the responsible food vehicle due to delays in notification, in beginning an investigation and to difficulties in obtaining samples of suspected food, etc. In some outbreaks the organism was introduced by poultry-meat, but other foods were implicated epidemiologically as the vehicles of spread following cross-contamination in the kitchen (Watson, 1985; Report, 1986). Similarly, it was not unknown for one supply of poultry-meat to contaminate a second unrelated batch (Neilson *et al*, 1984). In point source outbreaks such as in a hospital or a restaurant, food remnants or supplies from the same batch may more often be available for examination (Levin, 1986). Only in a few outbreaks is it possible to demonstrate the presence of the same organism in the flocks of origin. More frequently, however, poultry-meat may only be implicated on epidemiological evidence, but this together with the knowledge of serotypes currently circulating in the industry is sufficiently incriminating.

The recorded number of 2245 persons affected during the 6 years is likely to be a considerable underestimate of the true incidence of poultry-borne salmonellosis in Scotland, with perhaps only 1% of symptomatic cases being reported (Aserkoff, Schroeder & Brachman, 1970). Only household and general outbreaks are discussed here, and no account is taken of the many sporadic cases of infection, a significant proportion of which, from the epidemiological evidence available and the serotypes involved, were most probably also associated with poultry-meat.

During 1980–5 poultry-meat accounted for more than half of all outbreaks and persons affected and within the limitations of under-reporting it is clear that poultry-meat is now the single most important vehicle in food-borne salmonellosis in Scotland.

The financial consequences of poultry-borne salmonellosis are considerable and have recently been evaluated (Yule *et al*, 1988). This estimated an average mid-cost per case in excess of £2240 with a Scottish annual cost of £5·5 million (range £0·34–10·7 million) depending on the allowance for under reporting and intangible factors such as the value of lost life. These estimates are comparable with those made for milk-borne salmonellosis (Cohen *et al*, 1983) which were an important element in the evaluation of the subsequent introduction of heat treatment control measures. It is likely that such costs, which if taken on a population basis are approximately 10% of the total for the United Kingdom, will continue and possibly escalate if no effective preventive action is taken.

Poultry-meat is one of the cheapest forms of animal protein. As a result consumption rose by almost 100% between 1966 and 1984 (National Food Survey Committee, 1980–5). To maintain the price advantage over other meats there will be continuing pressure on the poultry industry to contain costs and there will be less incentive to actively reduce the salmonella problem.

Further efforts will have to be made to reduce the degree of salmonella carriage by poultry flocks despite there usually being no detrimental effect on the health of the birds. The control of generation transmission, already undertaken by many poultry companies, such as egg hygiene, similarly requires to be intensified.

This must be accompanied also by a reduction of salmonellas in poultry feed. There is little evidence to indicate that the Disease of Animals Protein Processing Order, 1981, and the Importation of Processed Animal Protein Order, 1981, have been successful in reducing the weight of salmonella contamination in poultry feed

(Kirby & Wray, 1986). There is unlikely to be any benefit from control programmes to reduce horizontal or vertical transmission of infection if there is a constant risk of re-introduction of the organisms. The ideals behind the two Orders are sound, but they require to be more strictly enforced. In addition the development of techniques for competitive exclusion in young birds (Impey, Mead & George, 1982) could be more actively pursued under commercial conditions. This measure may reduce the degree of salmonella carriage in broiler flocks at the time of slaughter.

Inspection of poultry carcases plays little part in the control of the spread of salmonellas unless gross visible carcase contamination is occurring. Indeed, it can be argued that the presentation of viscera for inspection can lead to increased carcase contamination. The importance of an inspection service lies in the overall control of plant hygiene. Even if there is a significant reduction in the number of infected birds arriving at the processing plant there will still be opportunities for cross-contamination with the high throughput of modern poultry plants. Despite improvements such as the contra-flow spin chiller, air chilling, more frequent washing of carcases, etc., considerable cross-contamination still occurs. Equipment design has to be such that it will be washable between carcases with easy access for regular cleaning and disinfection.

Despite many improvements on farms and in the processing plants, contaminated carcases continue to reach the consumer. An ongoing education campaign must therefore be maintained advising on correct procedures for commercial and domestic kitchen hygiene. The value of such campaigns in recent years is demonstrated by there having only been a relatively small seasonal increase in the incidence of poultry-borne infection over the Christmas and New Year period, reflecting the concentration in advertising that has traditionally occurred at this time of year. Perhaps such a campaign should be maintained all year.

It may be, however, that the most effective control method is by rendering the final product 'safe' for human consumption, similar to measures which have already been accepted and proven for other 'at risk' raw foods such as the mandatory heat-treatment of ice cream, liquid egg, and most recently in Scotland, of cows' milk. Pasteurisation is unsuitable for reducing the bacterial load of poultry-meat. The only treatment which is at present practical is the use of non-ionizing radiation, a process not at present generally permissible in the United Kingdom although a recent report (Advisory Committee on Irradiated and Novel Foods, 1986) has recommended its use within limits which are suitable for poultry-meat for human consumption. Irradiation has been accepted by the World Health Organization and other international authorities as a satisfactory food process (F.A., I.A.E.O. & W.H.O., 1981). Many countries already permit its use in specific foods including poultry-meat, and standards and a code of practice have been established (Codex Alimentarius Commission, 1984). In Scotland, a recent report (Yule *et al.* 1986) indicates that the public health benefits outweigh the costs of irradiating poultry-meat.

We wish to thank Mrs S. Jardine and Miss I. Patterson for secretarial assistance, Mr T. W. Hill for data analysis and all our colleagues involved in investigating the outbreaks reported.

REFERENCES

ADVISORY COMMITTEE ON IRRADIATED AND NOVEL FOODS (1986). *Report on the Safety and Wholesomeness of Irradiated Foods*. London: HMSO.

ANON. (1987). U.K. facts and figures. *Poultry World*, September, 1987.

ASERKOFF, B., SCHROEDER, S. A. & BRACHMAN, P. S. (1970). Salmonellosis in the United States: a five year review. *American Journal of Epidemiology* **92**, 13–24.

BELL, J. & WRAY, C. (1985). Animal Salmonellosis 1985. *Annual Summary*. Ministry of Agriculture, Fisheries and Food, Welsh Office Agriculture Department, Department of Agriculture and Fisheries for Scotland.

BIGGS, P. M. (1978). The veterinary profession and an intensive poultry industry. *Veterinary Record* **103**, 251–255.

COHEN, D. R., PORTER, I. A., REID, T. M. S., SHARP, J. C. M., FORBES, G. I. & PATERSON, G. M. (1983). A cost benefit study of milk-borne salmonellosis. *Journal of Hygiene* **91**, 17–23.

COLLIER, P. W., SHARP, J. C. M., FORBES, G. I. & HILL, T. W. (1985). Surveillance programme for foodborne infections and intoxications in Scotland 1985. Information Services Division, Common Services Agency, Edinburgh, ISSN 0263–8754.

GILBERT, R. J. (1983). Food Microbiology: Advances and Prospects. *Society for Applied Bacteriology Symposium Series*, no. 11, (ed. T. A. Roberts and F. A. Skinner) pp. 47–66 London and New York: Academic Press.

HOUSEHOLD FOOD CONSUMPTION AND EXPENDITURE (1980–5). *Annual Reports of the National Food Survey Committee*. London: HMSO.

IMPEY, C. S., MEAD, G. C. & GEORGE, S. M. (1982). Competitive exclusion of salmonellas from the chick caecum using a defined mixture of bacterial isolates from the caecal microflora of an adult bird. *Journal of Hygiene* **89**, 479–490.

KIRBY, D. & WRAY, C. (1986). Veterinary aspects and prospects for control. *P.H.L.S. Microbiology Digest* **3**, no. 2, 12–13.

LEVIN, C. S. (1986). An outbreak of foodborne salmonellosis in a Lanarkshire maternity hospital. *Communicable Diseases (Scotland) Weekly Report*, no. 86/04, 5–7.

NEILSON, D., ADAMS, P., ANDERSON, S. & HAINES, D. (1984). Salmonella stanley 'strikes' miners. *Communicable Diseases (Scotland) Weekly Report, no.* 84/52, pp. vii–viii.

REILLY, W. J., SHARP, J. C. M., FORBES, G. I. & COLLIER, P. W. (1986). Poultry meatborne salmonellosis in Scotland. *Proceedings of 2nd World Congress Foodborne Infections and Intoxications*, pp. 294–297. Institute of Veterinary Medicine–Robert von Ostertage Institute, Berlin.

REPORT (1986). *The Report of the Committee of In quiry into an Outbreak of Food Poisoning at Stanley Royd Hospital*, London: HMSO. Cmnd. 9716.

SHARP, J. C. M., PATERSON, G. M. & BARRETT, N. J. (1985). Pasteurisation and the control of milkborne infections in Britain. *British Medical Journal* **291**, 463–464.

WATSON, J. (1985). Another 'fast reactor' in Caithness. *Communicable Diseases (Scotland) Weekly Report*, no. 85/49, pp. 5–6.

YULE, B. F., FORBES, G. I., MACLEOD, A. F. & SHARP, J. C. M. (1986). The cost and benefits of preventing poultry-borne salmonellosis in Scotland by irradiation. *Health Economics Research Unit, Discussion Paper*, no. 05/86, University of Aberdeen.

YULE, B. F., MACLEOD, A. F., SHARP, J. C. M. & FORBES, G. I. (1988). Costing of a hospital based outbreak of poultry-borne salmonellosis. *Epidemiology and Infection* **100**, 35–42.