Salmonellosis in general practice. Observations of cases and their households in Enfield

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SUMMARY

Nine hundred and seventeen Salmonella infections in 580 households were confirmed during a laboratory study of diarrhoea in general practices in a large urban area during the years 1953–68. This was an annual incidence of about 2/10,000 population. Salmonellas were found in nearly 2 % of new cases of diarrhoea investigated. Plural infections were found in 36 % of the households studied and 18 % of all contacts examined were shown to be infected. Among these contacts the infection rate was higher for children (24 %) than for adults (16 %). The duration of infection was longer than 2 months in nearly a quarter of the cases followed up, and intermittent excretion was observed in one-fifth. The commonest serotype was *Salmonella typhimurium*, but its incidence in the district declined especially after 1964. *S. typhimurium* infection provoked a severer enteritis but less general symptoms than did other salmonellas. Children were more susceptible than adults to salmonella infection, to illness and to prolonged excretion, but symptoms in index cases were as severe in adults as in children.

INTRODUCTION

Salmonellosis is a common cause of food poisoning in England and its place in outbreaks has been well documented. In contrast its sporadic occurrence in general practice has been studied less.

During the years 1953–68 such a study was made among a population of approximately 250,000 in general practices in Enfield. The family doctors in the area, the local health department, and the Edmonton public health department co-operated in the diagnoses and observation of the cases. The findings are reported below.

METHODS

The first confirmed case of salmonella gastro-enteritis in any household was listed as the index case and the home was visited by a health inspector. Infected households discovered during the follow-up of contacts were also visited and listed separately. A record was made of the age, sex and occupation of each member of the household, as well as the date of any symptoms and the suspected source of infection. Each person was asked to send a faecal sample to the laboratory. First

specimens were usually received before the start of treatment. Thereafter the patients were treated by their doctors in various ways.

Patients in whose faeces salmonellas were found were asked to send weekly specimens starting 3 or more days after concluding any antibacterial treatment, until a negative result had been found. The rest of the family were then re-examined. Most families were persuaded to remain under observation until two or three consecutive negative specimens had been collected from each infected person. Negative results from unsatisfactory or dry specimens were disregarded.

Eighty per cent of the faeces specimens sent for diagnosis were examined during the first week of illness. After microscopic examination, cultures were made on MacConkey and on deoxycholate citrate agar plates and from selenite-F enrichment broth on deoxycholate citrate agar. Common salmonella serotypes were recognised by standard techniques; rarer serotypes were identified at the Salmonella Reference Laboratory.

RESULTS

Incidence of ascertained infection

During the 16 years of the study approximately four-fifths of the population of Enfield were aged 15 years or over; children were distributed fairly evenly among the age groups 0–4 years, 5–9 years and 10–14 years.

A total of 917 individual salmonella infections were recorded, a mean annual incidence of approximately 2/10,000. Of these, 539 were index cases and a further 41 infected households were found during the follow-up of contacts. These 580 households represent nearly 1 % of the households in the area.

Source of infection

Forty-three of the 539 index cases arose in five foodborne outbreaks. One of these outbreaks was traced to a convalescent carrier preparing cream cakes (Cowlard & Thomas, 1963) and the remaining four to the contamination of cooked food with raw ingredients.

Attempts to trace the source of infection of the 496 sporadic index cases were usually unsuccessful. In at least 15 instances infection was probably contracted during foreign travel, five with *S. typhimurium* and ten with other salmonellas.

Serotypes

During the period from 1953 to 1968 the commonest salmonella serotype was *S. typhimurium*, which was isolated every year and accounted for two-thirds of the total incidence. *S. enteritidis, S. paratyphi B, S. thompson, S. heidelberg* and *S. newport* were the next most frequently encountered; other serotypes were much rarer (Table 1).

S. typhimurium infection differed from that with other salmonella serotypes in several important respects. For purposes of comparison all the latter have been grouped together and designated 'other salmonellas'.

From 1953 there was a continued decline in the number of *S. typhimurium* isolations annually followed by a pronounced drop after 1964, although no such

trend was seen with 'other salmonellas' (Table 2). To begin with *S. typhimurium* clearly predominated, but this was not so at the end of the period. Until 1964 more than three-quarters of all salmonellas were isolated in the summer half year, but afterwards the seasonal variation was slight (Fig. 1).

Table 1. *Salmonella serotypes isolated from index cases according to 4-year periods*

Serotype	1953–6	1957–60	1961–4	1965–8	Total 16 years	Number of years isolated
S. typhimurium	132	102	93	34	361	16
S. enteritidis	7	3	4	6	20	12
S. paratyphi B	18	2	3	—	23	8
S. thompson	8	7	2	—	17	6
S. newport	1	6	1	2	10	5
S. heidelberg	—	2	11	3	16	5
30 Other serotypes	15	13	41	27	96	1–5
Total	181	135	155	72	543*	—

* Included are 4 multiple infections.

Table 2. *Index cases according to year and salmonella group*

Year	S. typhi-murium	'Other salmonellas'	Total
1953	39	8	47
1954	39	4	43
1955	31	20	51
1956	23	16	39
1957	29	5	34
1958	32	9	41
1959	23	16	39
1960	18	3	21
1961	22	7	29
1962	25	27	52
1963	35	14	49
1964	11	13	24
1965	10	7	17
1966	10	5	15
1967	9	13	22
1968	5	11	16
Total	361	178	539

Age and sex

Of the 539 index cases, 361 were infected with *S. typhimurium* and 178 with 'other salmonellas'. The sex and age distribution differed in these two groups (Table 3). Fifty-eight per cent of *S. typhimurium* index cases were in children, whereas 58 % (also) of the index cases infected with 'other salmonellas' were in adults. This difference in the child/adult index case ratio between the two salmonella groups is highly significant ($P = < 0.001$). There were significantly more male than female adult index cases of *S. typhimurium*, but slightly more female than male index cases infected with 'other salmonellas'.

For both *S. typhimurium* and 'other salmonellas' the highest proportion of index cases arose in the youngest population groups (Table 4). Thus there were 5·2 salmonella index cases/10,000 p.a. among the youngest children (0–4 years) and only 0·7/10,000 among adults.
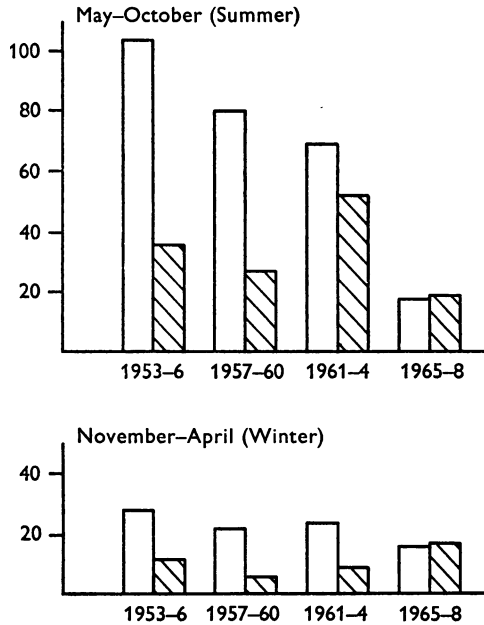

Fig. 1. Annual and seasonal incidence of index cases. □, *S. typhimurium*; ⊠, 'Other salmonellas'.

Table 3. *Index cases according to sex, age group and salmonella group*

Type of index case		*S. typhimurium*	'Other salmonellas'
Child	Male	119 (33%)	39 (22%)
	Female	91 (25%)	36 (20%)
Adult	Male	87 (24%)	46 (26%)
	Female	64 (18%)	57 (32%)
Total		361	178

Severity of illness

All the 539 index cases were sufficiently ill to have called in a doctor and achieved a bacteriological diagnosis. Two distinct criteria were used to assess the relative severity of index cases. These were: early admission to hospital for medical reasons, and a record of blood or pus cells in the faeces. Admission to hospital for social reasons was not included in assessing severity.

As shown in Table 5, a slightly higher proportion of patients infected with 'other salmonellas' than with *S. typhimurium* were admitted early to hospital—17 and 13 % respectively. In contrast nearly twice as many patients infected with *S. typhimurium* had blood or pus in their stools, 43 % as compared with 24 %, and

there was some indication that colitis persisted longer after *S. typhimurium* infection. Cells were seen in 15 of 56 (27 %) of patients infected by *S. typhimurium* whose faeces were examined in the second week of illness, but in only 3 of 32 (9 %) infected with 'other salmonellas'. *S. typhimurium* infections were thus more irritating to the epithelium of the gut than 'other salmonellas' but paradoxically a greater proportion of the 'other salmonellas' produced severe general symptoms with fever and prostration.

Table 4. *Case incidence according to age group*

Age group of index case	Total number of index cases	Mid-period population	Annual incidence/10,000 population
0–4 years	143	17,343	5·2
5–9 years	84	15,676	3·3
10–14 years	36	20,680	1·1
Child, age group unknown	22	—	—
All children	285	53,699	3·3
Adult 15 +	254	220,158	0·7
Total	539	273,857	1·2

Table 5. *Severity of cases according to salmonella group, age group and sex*

Salmonella group	Index case		Admitted early to hospital	Diagnosed at home		Total
				Cells found	No cells found	
S. typhimurium	Child	Male	18 (15 %)	43 (36 %)	58 (49 %)	119
		Female	12 (13 %)	48 (53 %)	31 (34 %)	91
	Adult	Male	4 (5 %)	42 (48 %)	41 (47 %)	87
		Female	12 (19 %)	21 (33 %)	31 (48 %)	64
	Total		46 (13 %)	154 (43 %)	161 (45 %)	361
'Other salmonellas'	Child	Male	5 (13 %)	9 (23 %)	25 (64 %)	39
		Female	12 (33 %)	7 (19 %)	17 (47 %)	36
	Adult	Male	6 (13 %)	12 (26 %)	28 (61 %)	46
		Female	8 (14 %)	14 (25 %)	35 (61 %)	57
	Total		31 (17 %)	42 (24 %)	105 (59 %)	178

Although as mentioned above the incidence of index cases was greatest in children, it was interesting to note that among index cases symptoms were of broadly similar severity in children and adults (Table 5).

Duration of infection

The duration of infection was taken to be from the onset of diarrhoea to the point midway between the last positive and first negative specimen of a clearance series.

Surveillance was only enforceable in those few cases carrying a specific public health risk, but most families were persuaded to co-operate voluntarily. Of the

539 index cases, 199 had three or more terminal negative specimens, 159 had two, and 66 had only one. These 66 cases have been included in an analysis of the duration of infection (Table 6) because the mathematical distribution of their durations was similar to that of the 258 cases with two or more final negatives. The last specimen examined was positive in 115 cases and six of these which were shown to be excreting salmonellas for 2 months or more are also included in the total analysed (430).

Table 6. *Duration of infection in index cases according to age and serotype*

	Age group	No. of cases analysed	< 2 weeks	2–< 4 weeks	4–< 8 weeks	2 months and longer	Lapsed from survey
S. typhimurium	0–4	90	13 (14%)	27 (30%)	23 (26%)	27 (30%)	18
	5–14	79	11 (14%)	29 (37%)	23 (29%)	16 (20%)	11
	< 15 age unknown	4	—	1	—	3	8
	15+	120	24 (20%)	40 (33%)	39 (32%)	17 (14%)	31
	Total	293	48 (16%)	97 (33%)	85 (29%)	63 (21%)	68
'Other salmonellas'	0–4	32	6 (19%)	6 (19%)	10 (31%)	10 (31%)	3
	5–14	27	6 (22%)	3 (11%)	10 (37%)	8 (30%)	3
	< 15 age unknown	3	1	1	—	1	7
	15+	75	19 (25%)	17 (23%)	22 (29%)	17 (23%)	28
	Total	137	32 (23%)	27 (20%)	42 (31%)	36 (26%)	41
Totals		430	—	—	—	99 (23%)	109

The duration of infection showed no sex difference. It was significantly longer in childhood and there was a tendency for infection with 'other salmonellas' to last longer than that with *S. typhimurium* (Table 6). Infection with *S. typhimurium* persisted beyond 2 months in 30% of preschool children, 20% of school children and 14% of adults; the corresponding figures for 'other salmonellas' were 31, 30 and 23%. Twenty-three per cent of all salmonella infections lasted longer than 2 months (Table 6), 10% (42) longer than 3 months and 4% (17) longer than 4 months. Two patients, a man of 44 infected with *S. typhimurium* and a woman of 63 with *S. enteritidis*, were still known to be infected when they left the district more than 9 months after the onset of their illness. The woman had had six courses of treatment with different drugs and antibiotics.

Intermittent excretion was demonstrated in 108 (one-fifth) of the 539 index cases and might have been disclosed more often had longer and closer supervision been practicable. Its occurrence was not related to age, sex, or salmonella group, but probably to treatment, since in 36 cases the second specimen in a series was an intervening negative. Such specimens were liable to have been taken shortly after antibacterial therapy and were discounted for surveillance purposes. In 72 cases a negative report intervened at a later stage, and in half of them more than one such intervening negative was recorded.

Household infection

Specimens of faeces were collected from other members of the households of 94 % of laboratory index cases. Of these 508 households 181 (36 %) were found to contain further infected persons, many without symptoms. The average number of additional persons tested in each household was 3·2, being rather more for child index cases (3·7) than for adults (Table 7). Taking all ages together, the contact infection rate was 18 % for each of the two salmonella groups. Regardless of the age of the index case, children were infected more often than adults, 24 % (150/634) of child contacts being infected compared with 16 % (155/983) of adults. This difference is highly significant statistically.

Table 7. *Household infection rate according to salmonella group,*
age group and sex

	Index Case	Number of households	Number of household contacts tested (all ages)	Average number tested per household	Number found positive	Rate of household infection (%)
S. typhimurium Child {Male	115	412	3·6	72	17
	Female	86	304	3·5	59	19
Adult {Male	82	234	2·9	35	15
	Female	60	137	2·3	33	24
Total		343	1087	3·2	199	18
'Other salmonallas' Child {Male	39	139	3·6	32	23
	Female	33	147	4·5	31	21
Adult {Male	40	99	2·5	17	17
	Female	53	137	2·6	15	11
Total		165	522	3·2	95	18

Child index cases had more child contacts than adults and household infections were more frequent when the index case was a child. Table 7 shows that for *S. typhimurium* the household infection rate was higher for female index cases, but that the reverse was true for 'other salmonellas'.

In 20 households more than one pathogen was found. These multiple infections included *Shigella sonnei*, enteropathogenic *Escherichia coli*, *Giardia lamblia*, and plural salmonella species. No less than four salmonella serotypes were recognized in one family after a holiday abroad (Thomas & Cowlard, 1965).

DISCUSSION

Since the survey in Massachusetts by Rubenstein, Feemster & Smith (1944), there have been few epidemiological reports of salmonellosis in family practice and the current study appears to be the first long-term investigation of this kind made in England. Despite the difference of time and place, our observations have been very similar to those made in the American study.

The investigation had several advantages: a reasonably stable community, the co-operation of family practices in the same district over many years, the active

participation of the public health departments throughout, and co-ordination by a single laboratory of the Public Health Laboratory Service.

Although salmonellosis is a common cause of food poisoning accounting for nearly two-thirds of such incidents (Cockburn & Vernon, 1969; Evans, 1970), the findings in Enfield confirmed reports from other areas that salmonellosis is not a common cause of diarrhoea in general practice (Thomas & Charter, 1956; Tuckman et al. 1962; Knox, MacNaughton, Laurence & Robertson, 1967). During the period of the study it accounted for about 2 % of diarrhoeas investigated and the findings suggested that a doctor in Enfield might have had an infected household diagnosed about once every 3 years. In the social conditions prevailing there was little evidence of case-to-case spread outside the household or even within it, since the 36 % of households in which more than one person was found to be infected may often have shared a common food source, although this was not obvious unless infected contacts had symptoms. The only outbreaks observed were all directly related to food from a common source. During the study infected children were found in schools and day nurseries without associated cases. However, this may have been because the hygiene in the Enfield nurseries was of a high standard, and nursery outbreaks are nevertheless a recognized hazard. No hospital outbreak was discovered, but they too are a serious problem when they arise. The study emphasizes that the liability to salmonella infection and to gastro-enteritis decreases with the age of the child and is least in adults. Clearly the susceptibility of infants and their tendency to prolonged infection—also shown by the study—must be taken into account in the control of human salmonellosis. It was of interest that, as reported by Rubenstein and his colleagues in 1944, the ratio of child to adult infections was greater for S. typhimurium than for 'other salmonellas'. The reasons can only be conjectured, but S. typhimurium is endemic and relatively small numbers, sufficient to produce disease in children but not in adults, may be more frequently ingested than with other salmonella species.

The continuing decline in the number of S. typhimurium infections in the area and their more rapid fall from 1964 onwards was associated with the loss, after 1964, of a previously marked summer predominance of all salmonellas. This was apparently a local phenomenon, since there is no evidence from the national returns of salmonella isolations made to the PHLS of a comparable reduction in summer infections. Enfield, like most of the country during the period concerned, experienced changes in food technology and distribution. Commercial and domestic refrigeration increased as did the pasteurization of milk supplies, and in 1964 the liquid egg pasteurization regulations were enforced (Statutory Instrument, 1963). In addition, from 1964 the Enfield Health Department took a very active interest in food hygiene, arranging public exhibitions as well as the regular inspection of premises and certain categories of food handlers. It may be that this local interest contributed to the difference from the national pattern.

The findings emphasize the common observation that salmonella infections are often prolonged. Half of them lasted longer than a month and 10 % persisted beyond 3 months. Excretion was more persistent in young children and after infection with 'other salmonellas'. The traditional view that a single negative

specimen is insufficient for clearance was substantiated. Sharp (1970) recorded recurrent excretion of salmonellas after three or more negatives in nearly 5 % of cases in several outbreaks and concluded that six final negatives should be required.

There is some evidence that antibiotics may prolong salmonella excretion (Dixon, 1965; Azerkoff & Bennett, 1969) and many of our cases received anti-bacterial treatment which varied with the fashions over 16 years and which may have prolonged some infections.

The study showed clearly that, although systemic symptoms tended to be more evident with 'other salmonellas' than with *S. typhimurium*, colitis was more severe with the latter. The potential severity is underlined by Boyd's (1968) observation of an acute colitis with crypt abscess formation and fibrinoid necrosis in the post-mortem examination of four patients who died of *S. typhimurium* infection. Finally, in spite of the greater susceptibility of children, but perhaps indicative of a threshold of severity at which medical help is sought, symptoms in index cases were as severe in the adult as in the child.

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