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A demographic survey of campylobacter, salmonella and shigella infections in England

A Public Health Laboratory Service Survey*

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SUMMARY

Five laboratories serving a population of 1·5 million participated in a 2-year survey of campylobacter, salmonella and shigella infections in patients suffering from gastrointestinal symptoms. In total, 33857 faecal specimens were examined of which 5·5% yielded campylobacters, 3·4% salmonellas and 0·8% shigellas; incidence of infection (per 100,000 population per year) was 58, 38 and 9 respectively. Peak incidences occurred at different ages for each organism: campylobacter, 1–4 years (183); salmonella, less than 1 year (181); shigella, 1–4 years (17). There was a secondary peak in campylobacter incidence in patients aged 15–24 years (87), which was not seen with salmonella or shigella infections.

By recording the age and sex of all patients submitting faecal specimens, it was shown that sampling rates were disproportionately high in infants aged less than 1 year (12:1 relative to other ages). Thus the percentage of faecal samples positive in infants – in sharp contrast to incidence values – was the lowest of any age group for all three organisms. By taking the numbers of faecal specimens tested as denominators in this way, the highest campylobacter isolation rates were in young adults, with a notable male predominance in the 15–24 year (1·7:1) and 45–54 year (1·6:1) age groups. This male predominance was accentuated during the summer (2·1:1) when incidence was generally high. The maximum percentage isolation recorded by any laboratory was 32·5% in males aged 15–24 years in June.

The reasons for this pattern of campylobacter infection are unknown, but the similarity of the results between laboratories and the regularity of the seasonal fluctuations recorded over the last 6 years indicate that the sources and routes of infection are geographically similar and stable, yet different from those of salmonellosis.

INTRODUCTION

Campylobacters are the most frequently identified agents of acute infective diarrhoea in developed countries. The number of campylobacter isolations reported to the Public Health Laboratory Service (PHLS) Communicable Disease Surveillance Centre (CDSC), which receives laboratory reports from about 300

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laboratories in England and Wales, has been rising steadily since reporting began in 1977. In 1978 there were 6300 reports; by 1982 the total had risen to 12800, and now (1986) it has reached nearly 25000. Increased awareness of a newly described disease explains much of the initial increase, but this factor is unlikely to have affected the figures in recent years. Moreover, reports of salmonella and shigella isolations, which might be expected to reflect trends due to increased sampling, showed no great change over the same period (salmonella 10500–14800; shigella 4600–4700). Thus the incidence of campylobacter enteritis seems to be increasing, and we do not know why.

Although the PHLS system of laboratory reporting provides valuable information, only positive results are reported. The denominators, i.e. the numbers from which the positives are obtained, are unknown. Individual laboratories have recorded such data for campylobacters (Butzler & Skirrow, 1979), but isolations are usually too few to stand analysis by age, sex and season. In the hope that such analyses would throw some light on the epidemiology of campylobacter enteritis, five laboratories undertook a 2-year survey in which such denominators were recorded.

MATERIALS AND METHODS

Laboratories and populations served

Five laboratories took part in the survey: the public health laboratories at Bath, Exeter, Hereford and Southampton and the microbiology laboratory of the Worcester Royal Infirmary. These laboratories provided the main diagnostic microbiological service to their respective hospitals and communities. The population served amounted to just over 1·5 million (Table 1). Three laboratories (Bath, Hereford and Worcester) served essentially rural farming communities with some light industry. The Exeter and Southampton laboratories, situated on the south coast of England, served mixed urban and rural communities, but with a predominance of specimens from urban areas. The Exeter population contained an unusually high proportion of retired elderly people (20·7% aged 65 years or more compared with a national average of 15·2%), but the age and sex distribution of the combined study population was close to the national average.

Faecal specimens

All faecal specimens submitted from patients suffering from gastrointestinal symptoms during 1983 and 1984 were included in the study. Specimens from healthy people for screening (e.g. food handlers, contacts) were excluded. Repeat specimens from patients whose first specimens were positive for an enteric pathogen were also excluded.

Large clusters of isolations from two salmonella outbreaks were counted as one isolation each. No attempt was made to distinguish family or other small suspected outbreaks.

Patient data

The age and sex of all patients submitting specimens (both negative and positive) were recorded. Any history of foreign travel within 2 days of the onset

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Table 1. *Populations served by the five participating laboratories, crude isolation rates and crude incidence of campylobacter, salmonella and shigella infections, 1983–4*

Laboratory	Type of community	Population served (× 1000)	Specimens examined	No. positive (%)			Incidence (per 100000/y)		
				Campyl-obacter	Salmonella	Shigella	Campyl-obacter	Salmonella	Shigella
Bath	Rural	388·9	7871	650 (8·3)	197 (2·5)	75 (1·0)	75	25	10
Hereford	Rural	195·1	3674	272 (7·4)	166 (4·5)	35 (1·0)	70	43	9
Worcester	Rural	235·0	4500	362 (8·0)	119 (2·6)	32 (0·7)	77	26	7
Exeter	Semi-urban*	297·1	7627	246 (3·2)	307 (4·0)	56 (0·7)	39	50	9
Southampton	Semi-urban*	408·4	10192	341 (3·3)	360 (3·5)	65 (0·6)	39	44	8
Total/mean		1524·4	33857	1873 (5·5)	1149 (3·4)	263 (0·8)	58	38	9

* See text for definition.

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of symptoms was recorded for patients who were campylobacter-positive; these patients were deemed to have acquired their infections abroad.

Age-specific incidence was calculated by dividing the number of isolations in a given age group by the population in that age group and expressing the result per 100000 per year.

Bacteriology

Faecal samples were cultured according to the methods routinely in use at each laboratory. For campylobacters this consisted of direct plating of faeces on a campylobacter-selective agar (containing vancomycin, polymyxin B and trimethoprim) incubated at 42–43 °C, and for salmonellas and shigellas direct plating on deoxycholate citrate medium, with additional enrichment in selenite broth. Campylobacter isolates were identified according to species and biotype (Skirrow & Benjamin, 1980).

RESULTS

The results in each of the 2 years of the survey did not differ significantly, so all subsequent analyses were done on the combined figures for the 2 years.

Crude isolation rates and incidence

The total numbers of faecal specimens examined, and the total numbers of specimens positive for campylobacters, salmonellas and shigellas in each laboratory are shown in Table 1. The three laboratories serving predominantly rural farming communities had twice the incidence of campylobacter infection as had the two serving the more urban communities (Exeter and Southampton).

Age-specific incidence

Age-specific incidences are shown in Fig. 1. Although the average incidences differed between laboratories, the age distributions of campylobacter and salmonella infections were similar in each. All laboratories showed a peak incidence of campylobacter infection in children aged 1–4 years, with a secondary peak either in the 15–24- or 25–34-year age group, and a peak incidence of salmonella infection in children under 1 year old.

Analysis of the combined campylobacter results by sex showed somewhat higher incidences in males between the ages of 1 and 24 years.

Age-specific sampling rates

Fig. 2 shows the age-specific faecal sampling rates for the combined laboratories. In all laboratories sampling rates in infants greatly exceeded the sampling rates at other ages (roughly by a factor of 12). Over the age of 5 years the rates remained more or less constant except for a slight rise in people aged 65 years or more. Boys were sampled more often than girls (ratio 1·41:1 at age 1–4 years), but young women were sampled more often than young men (ratio 1·26:1 at age 15-24 years).

Age-specific percentage isolation rates

The percentages of faecal specimens positive within each age group are shown in Fig. 3. Again, despite differences in average isolation rates between laboratories,

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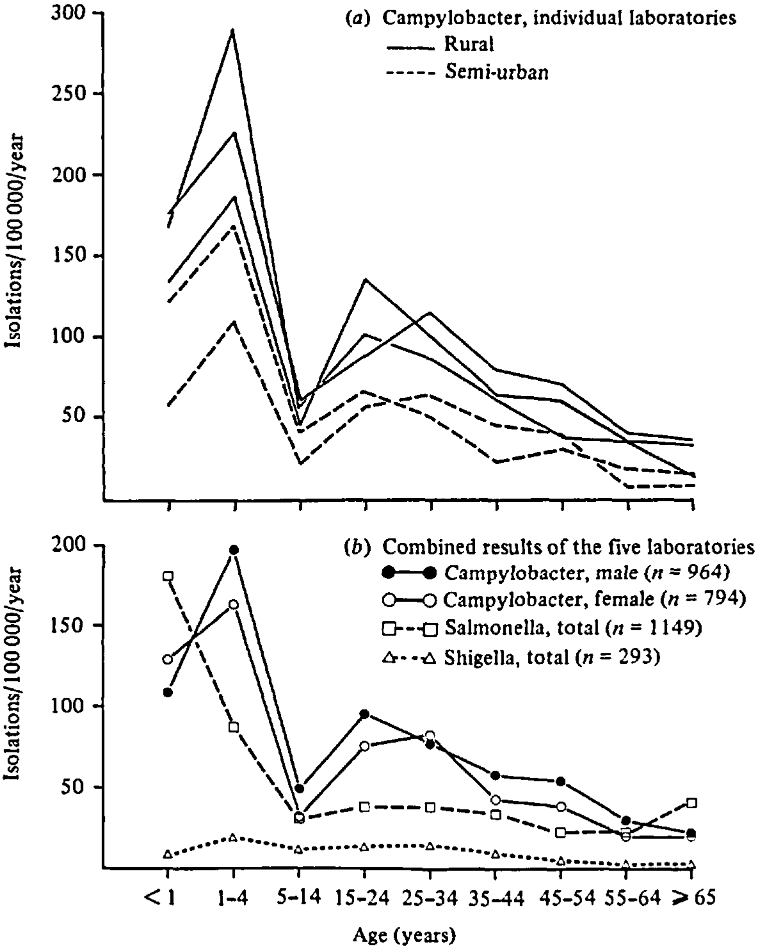

Fig. 1. Age-specific incidences of campylobacter, salmonella and shigella infections.

the age distribution patterns were essentially the same in each. Owing to the high infant sampling rates described above, they were strikingly different from the corresponding age-specific incidences (Fig. 1). Thus children less than 1 year old had the lowest proportion of faecal specimens positive for each of the three organisms (campylobacter 1·2%; salmonella 1·9%; shigella 0·1%), whereas the highest figures were in the 15–24-year age group in the case of campylobacters (9·7%), or in children aged 5–14 years in the case of salmonellas (5·3%) and shigellas (1·8%). Moreover, the proportion of campylobacter-positive specimens was distinctly higher in men than women, notably in the 15–24-year age group (1·70:1) but also in late middle age, and the apparent excess of infections in boys aged 1–4 years present in the age-specific incidence figures was no longer apparent.

Seasonal variation

The distribution of campylobacter and salmonella isolations in each 4-week period of the year is shown in Fig. 4*a*. For ease of comparison, results are expressed as percentages of the annual totals. It will be seen that campylobacter isolations began to rise sharply during weeks 17–20, reaching a plateau during

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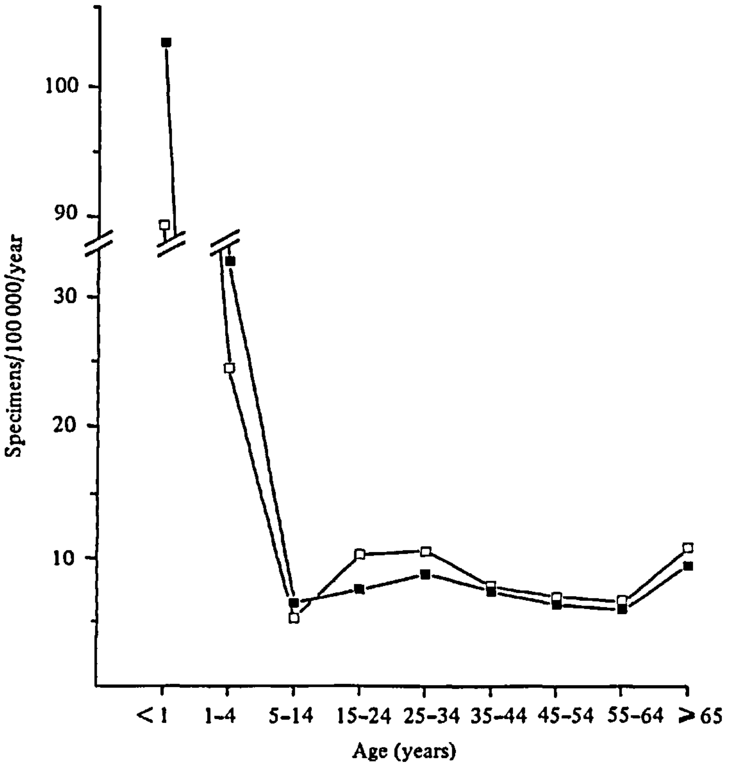

Fig. 2. Age-specific faecal sampling rates. Combined results of the five laboratories. ■—■, Male (n = 14888); □—□, Female (n = 16098).

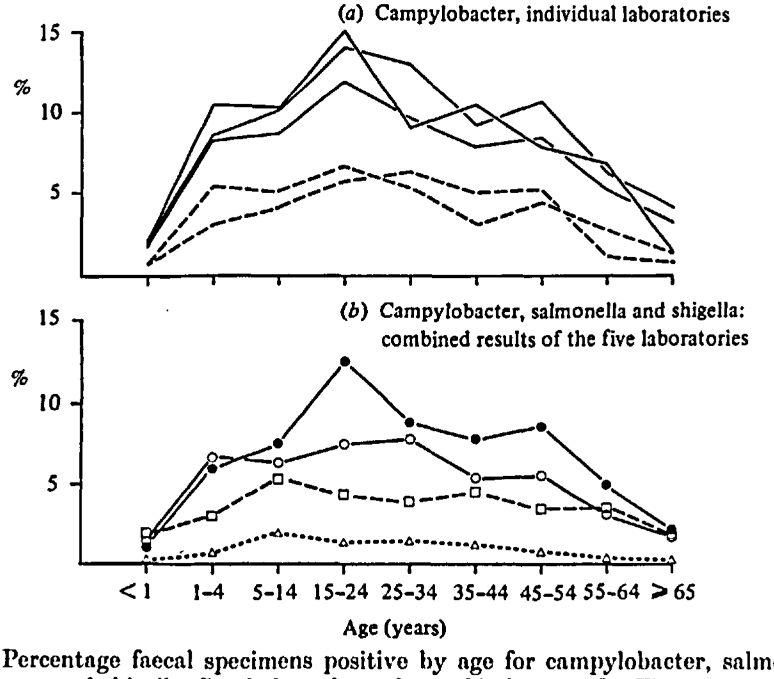

Fig. 3. Percentage faecal specimens positive by age for campylobacter, salmonella and shigella. Symbols and numbers of isolates as for Fig. 1.

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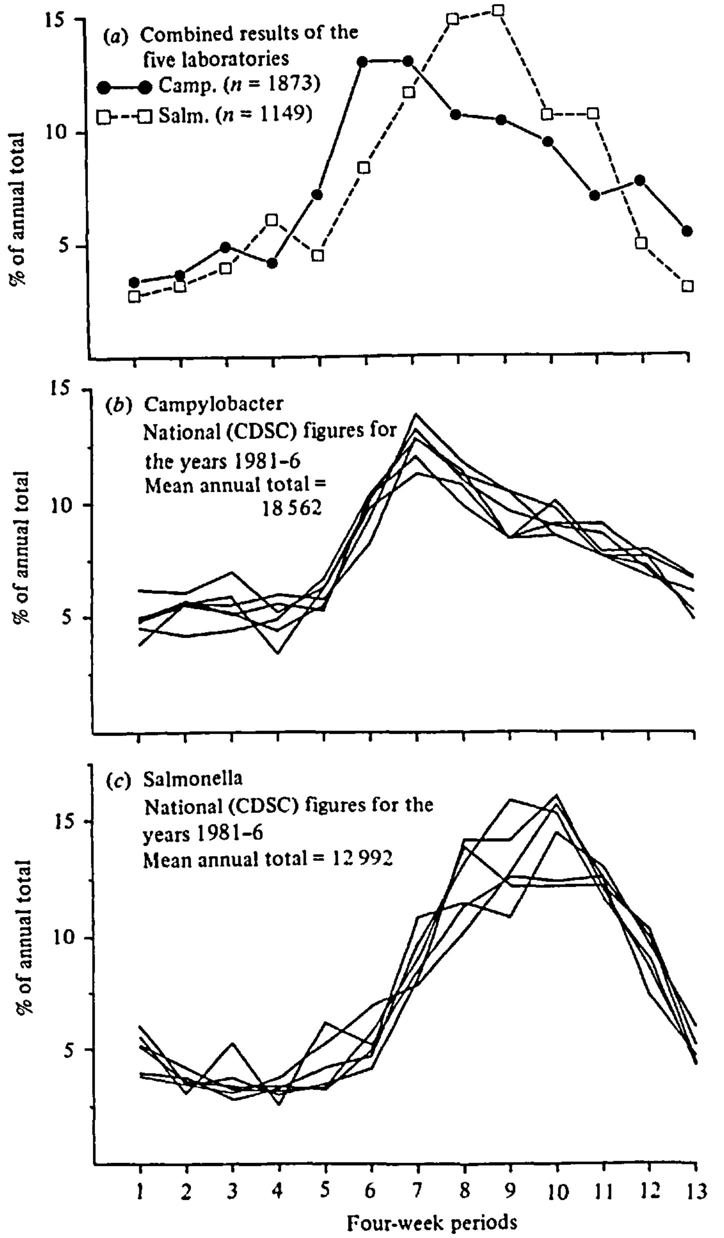

Fig. 4. Seasonal distribution of campylobacter and salmonella infections.

weeks 21–28, and then falling gradually back to a minimum in weeks 1–4. Salmonella isolations showed a somewhat sharper peak 8 weeks later than campylobacters.

These seasonal fluctuations in campylobacter and salmonella isolations were similar to those reported nationally (England and Wales); these have remained remarkably constant over the past 6 years (Fig. 4*b* and 4*c*). By contrast, no clear

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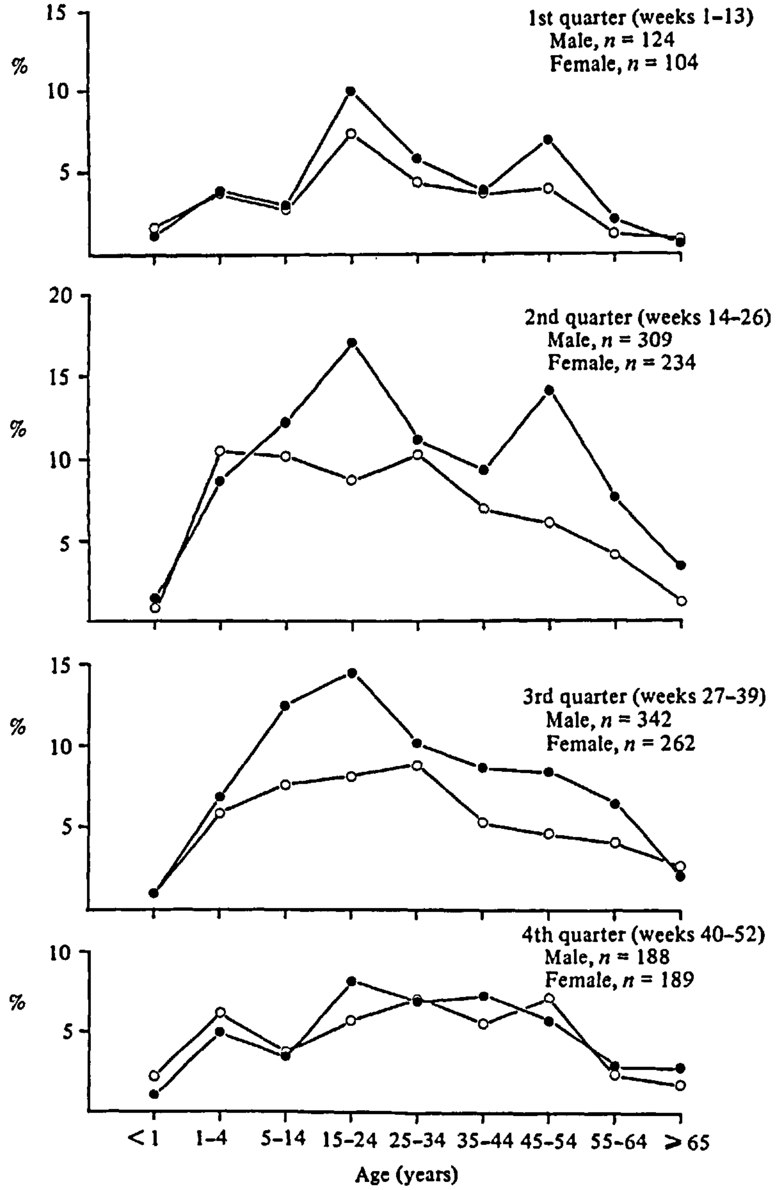

Fig. 5. Percentage faecal specimens positive for campylobacters by age and sex in each quarter-year. Combined results of the five laboratories. ●—●, Male; ○—○, Female.

seasonal pattern of shigellosis is evident in the national figures during the same period, although in the present study almost half of the shigella infections occurred in the 12-week period that coincided with the salmonella peak (mid-July to Sept.).

Age-specific campylobacter isolation rates analysed by quarter-year

Fig. 5 shows the percentage of faecal specimens positive for campylobacters by age and sex for each quarter of the year. It will be seen that there is a large

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difference between the graphs for the first and second quarters. The second-quarter figures are not only higher, but show an accentuated excess of infections in males aged 15–24 years and 45–54 years, a feature that persists into the third quarter but almost disappears during the rest of the year. This trend was even more pronounced during weeks 23–26 (roughly the month of June), when 24% of faecal samples from males aged 15–24 years were campylobacter-positive; the highest rate (32·5%) was recorded by the Hereford laboratory for weeks 23–30 (June–July).

Foreign travel

The proportion of patients who developed campylobacter infection abroad or within 2 days of their return home ranged from 3·7% (Exeter) to 16·9% (Worcester), with an average of 11·5% for all five laboratories. These imported infections occurred more or less evenly throughout the year, so their exclusion did not materially alter the seasonal variation shown in Fig. 4*a*; nor did their exclusion alter the age and sex distribution patterns portrayed in Figs 3 and 5.

DISCUSSION

The crude isolation rates are generally in keeping with those reported from Europe, North America and other developed regions. Most studies show the order of frequency: campylobacter, salmonella, shigella, as in our study. The campylobacter isolation rate of 5·5% is close to the mean figure of 7·1% (range 4·5–13·9%) derived from 13 surveys listed in the review by Blaser, Taylor & Feldman (1983). Lower figures have been recorded, notably 2% in a recent survey in Northern Ireland (Lafong & Bamford, 1986) and 2·1% in Canada (Coles *et al.* 1985).

Reports of incidence are more variable since they are influenced by the intensity of sampling. A prospective six-laboratory survey in Seattle, U.S.A., gave closely similar incidences to ours for campylobacter and salmonella infections, although the incidence of shigellosis was higher (Johnson & Nolan, 1985). By contrast, passive surveillance, such as the multi-state survey reported by Finch & Riley (1984), tends to give much lower figures (1·8–20·8 per 100000). Yet genuine differences do occur. In a large survey in West Germany, Kist & Rossner (1985) isolated campylobacters from patients living in rural areas nearly twice as often as from those living in urban areas. This ratio was similar to that found in our study between the laboratories serving rural and semi-urban populations (Table 1).

Analysis of incidence by age and sex shows some close parallels between our results and those from North America. The graphs presented by Finch & Riley (1984), Riley & Finch (1985), Johnson & Nolan (1985) and Hopkins & Olmsted (1985) are almost replicas of ours except for somewhat higher incidences of campylobacter infection in children aged less than 1 year. A particular point of similarity is the secondary peak in the incidence of campylobacter infection in young adults, which is not seen in the case of salmonella or shigella infections.

There are inherent disadvantages in measuring incidences that depend on passive sampling. This is plainly shown by our age-specific sampling rates, in

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which children under the age of 1 year were sampled 12 times more often than other age groups (Fig. 2). Although infants almost certainly have diarrhoea more often than adults, there are factors that proportionally increase infant sampling rates: mothers are more likely to seek medical advice for infants than older children, and doctors have a low threshold for sampling infants because of their vulnerability to dehydration. By taking the numbers of faecal specimens tested (by age and sex) as the denominators, these distortions can be avoided, although different distortions remain.

When our results were expressed in this way, i.e. percentage of faecal specimens positive within each age group, they appeared very different from the age-specific incidences. Infants had the lowest isolation rates and young adults (15–24 years) the highest (Fig. 3). Not only did this form of analysis indicate the importance of campylobacter infection in young adults, but it also revealed a notable predominance of infection in young and late middle-aged men. The latter was not evident from the incidence figures, because they did not take into account the fact that young women were sampled more often than young men (women are more closely in touch with their doctors through consultations for family planning, pregnancy and children). That the predominance of infection in men was real is supported by the fact that there was no equivalent excess of salmonella infections (results not shown). Hopkins & Olmsted (1985) also found an unexplained excess of campylobacter infection in young men and boys in Colorado, U.S.A.

The seasonal distribution of infection in the present survey was similar to the national pattern. The high summer incidences of campylobacter and salmonella infections in temperate climates are well known, but the reasons for them are not. The remarkably regular seasonal distribution of these infections in England and Wales, particularly for campylobacters (Fig. 4*b*), suggests that the sources and modes of transmission are stable and constant, though different for the two organisms.

The predominance of campylobacter infection in men during the summer requires explanation. The pursuit of outdoor activities, such as water sports and camping at sites without properly treated water supplies, would explain some of these cases. The Hereford laboratory results, which showed the highest isolation rate in males aged 15–24 years (32·5%) and the highest male-to-female ratio at this age (2·3:1), supports this, as 22% of the campylobacter-positive men of this age were servicemen who regularly participated in field exercises.

A striking excess of campylobacter infections in men was reported by Vernon *et al.* (1984) in American university students: 23·2 per 1000 in men and 4·5 per 1000 in women – both extraordinarily high incidences and far above anything in our study. A subsequent case-control study attributed these high rates to the faulty preparation and consumption of undercooked chicken by the students, who were inexperienced in such matters (Tauxe, Deming & Blake, 1985). The handling and preparation of chickens, which are a major source of campylobacters, by inexperienced trainee chefs was identified as a risk factor in the Poole and Dorchester area of the UK by Pearson *et al.* (1985). Occupational exposure to chickens probably accounted for five of the young male cases in the Hereford laboratory.

Epidemiological studies of this sort often pose more questions than they answer.

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Ours has provided more complete data on age- and sex-specific infection rates for future comparison, but the predominance of campylobacter infection in young men in the summer and the regularity of the seasonal fluctuations require explanation. The similarity of seasonal trends and age distribution of infection between laboratories in the UK and USA indicate that the sources and routes of campylobacter infection are geographically similar and stable, though different from those of salmonella infection. Case-control studies are needed to assess possible risk factors for the acquisition of infection, particularly around the time of the early summer rise of incidence.

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