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The seasonal distribution of campylobacter infection in nine European countries and New Zealand

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SUMMARY

In all temperate countries campylobacter infection in humans follows a striking seasonal pattern, but little attention has been given to exploring the epidemiological explanations. In order to better characterize the seasonal patterns, data from nine European countries and New Zealand have been examined. Several European countries with weekly data available showed remarkably consistent seasonal patterns from year to year, with peaks in week 22 in Wales, week 26 in Scotland, week 32 in Denmark, week 30 in Finland and week 33 in Sweden. In Europe, the seasonal peak was most prominent in Finland and least prominent in Scotland and Austria. In New Zealand the seasonality was less consistent since the peak was more prolonged. Possible explanations for the seasonal peaks are discussed. Research into the causes of campylobacter seasonality should help considerably in elucidating the sources of human infection.

INTRODUCTION

Campylobacter is one of the commonest causes of gastroenteritis [1] but its epidemiology is far from clear [2]. This is in contrast to salmonella where reservoirs and transmission routes are well documented [3]. Campylobacters have been isolated from a wide range of domestic and wild animals, but their relative importance as sources for human infection is not clear [4]. Outbreaks of campylobacter have primarily been linked to water [5], inadequately pasteurized milk [6] and poultry [7]. However, most cases appear to be sporadic [4] for which the vehicles are not necessarily the same as for outbreaks. Several case-control studies of sporadic cases in different

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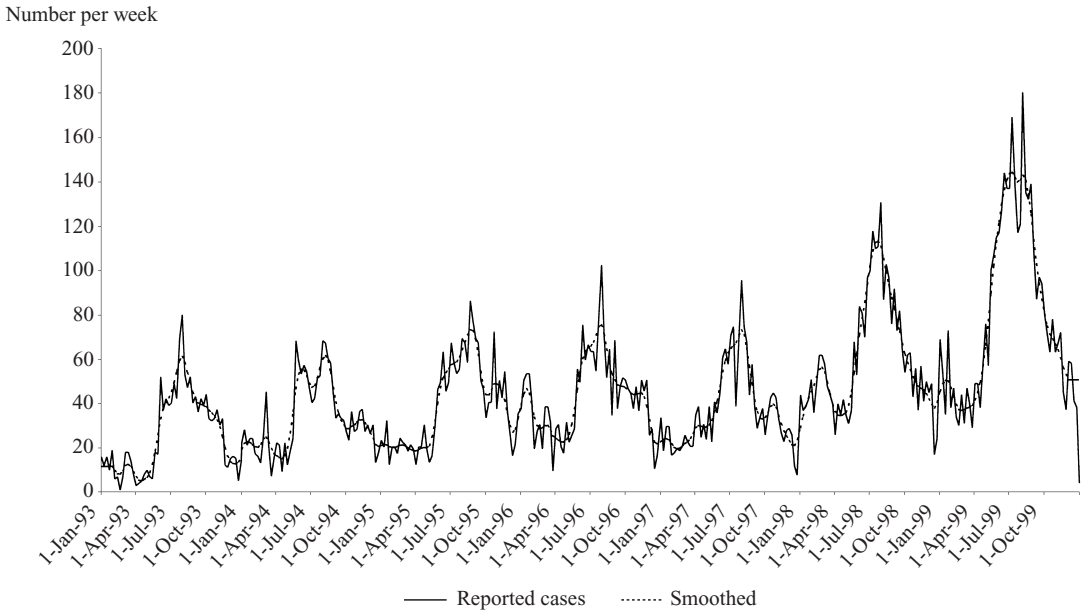

Fig. 1. Denmark, 1993–9.

settings [8–11] have identified a range of risk factors, primarily consumption of undercooked chicken, raw dairy products, untreated waters and contact with pets and cattle. However, the attributable fraction explained by all these variables combined is never more than 50%. More than 20 years after Skirrow's description of selective culture medium for campylobacter [12], the vehicles of most cases of campylobacter infections remain unexplained [2].

One distinctive feature which should provide clues to the sources of human infection is seasonality. For example, investigation of the spring surge in cases in the United Kingdom identified consumption of milk from milk-bottles whose tops have been pecked by birds as one important source of infection [13, 14]. However, at best this explains only 20% of the excess of human cases in May. A similar seasonality has been described in many other countries in temperate regions [15–17]. In order to characterize seasonality more precisely and generate hypotheses about transmission, a multinational study was set up to describe the seasonal distribution of campylobacter infection in humans in different European countries and New Zealand, based on available surveillance data.

MATERIAL AND METHODS

Weekly reports of campylobacter isolates were obtained from routine, laboratory based surveillance in Wales, Scotland, Finland, Sweden, Denmark, Austria and New Zealand. The surveillance had national coverage in Wales, Scotland, Finland, Sweden and New Zealand. In Denmark surveillance covered approximately 71–92% of the country during 1993–8, excluding parts of greater Copenhagen and parts of Jutland, but 100% in 1999. Austrian data were obtained from four regions mainly in Styria. Data from 1993–2000 were analysed for Wales, from 1993–9 for Scotland, Denmark and Sweden, from 1995–9 for Finland and from 1996–7 for Austria. The time variables in data presented in this paper were the week the specimen was provided by the patient (Finland), the week the specimen was received by the laboratory (Denmark, Wales and Austria), the week the laboratory reported the result to the clinician (Finland) and the week of report to the surveillance institute (Scotland, Sweden, New Zealand and Wales).

In order to summarize the seasonal pattern, allowing for random fluctuations and administrative irregularities in reporting, the series were smoothed using kernel smoothing [18] which gives robust estimates of the underlying trend in the presence of random fluctuations. From the smoothed series the week of the greatest incidence was estimated. In order to express the magnitude of this seasonal effect, the proportions of the annual cases occurring within ± 1, ± 2, ± 3 and ± 4 weeks of the peak was calculated.

In addition, monthly reports of campylobacter isolates were collected from Norway, Germany and France. Surveillance has national coverage in Norway. In Germany campylobacter cases are reported only in the former East Germany, whereas data from

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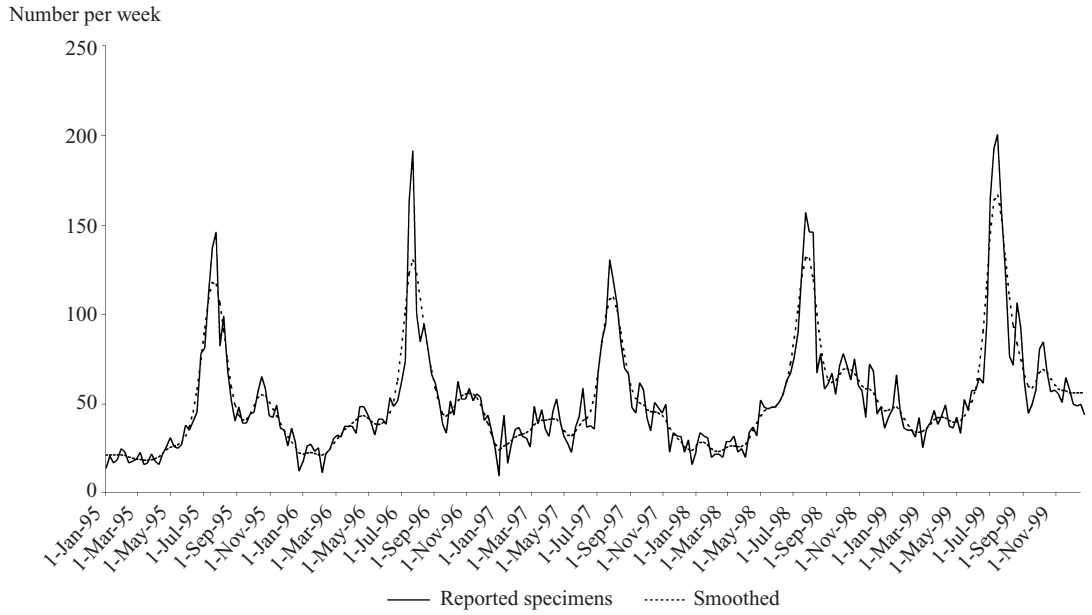

Fig. 2. Finland, 1995–9.

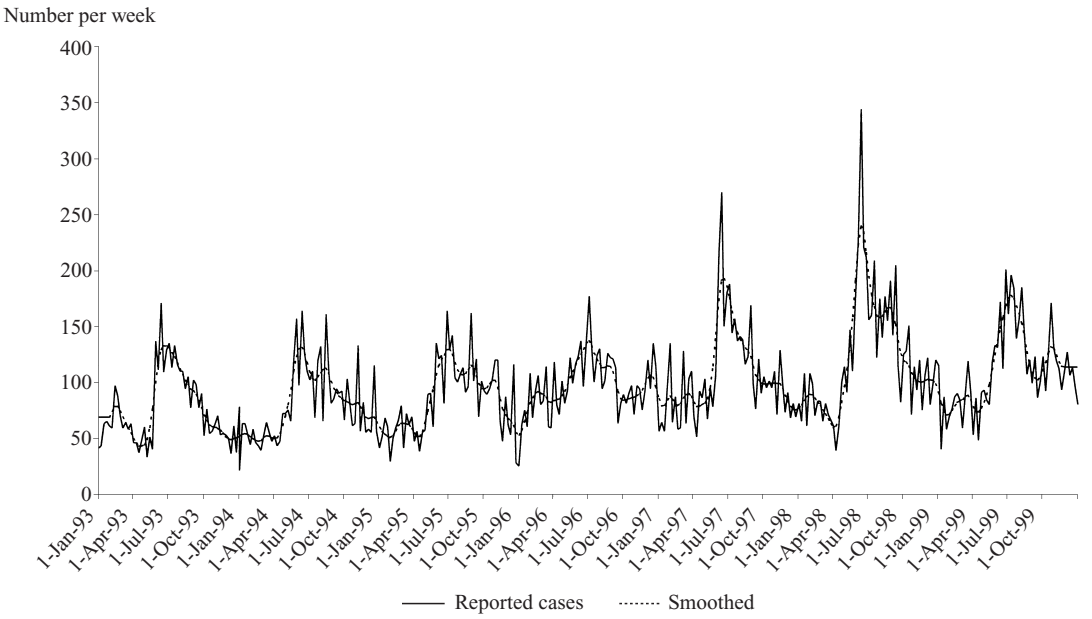

Fig. 3. Scotland, 1993–9.

France were based on reports from approximately 20 hospital laboratories spread over the French territory.

RESULTS

The distribution of isolates was analysed by week; 1158 from Austria, 16404 from Denmark, 13384 from Finland, 23781 from Wales, 39761 from New Zealand, 35386 from Scotland and 40841 from Sweden.

In Denmark (Fig. 1), Finland (Fig. 2), Scotland (Fig. 3), Sweden (Fig. 4) and Wales (Fig. 5) the seasonal peak in weekly reports were marked and quite consistent from year to year (Table 1). In Wales, the peak using report date was usually one week longer than the peak using specimen date. In New Zealand (Fig. 6) the annual peaks which occurred around the turn of the year were less consistent.

The average peak in Wales (week 22) was 4 weeks earlier than in Scotland (week 26) and 8–11 weeks ahead of Scandinavia (Denmark (32), Finland (30), Sweden (33)). Only 2 years data were available for Austria with peaks in week 22 and 33. In Norway, the

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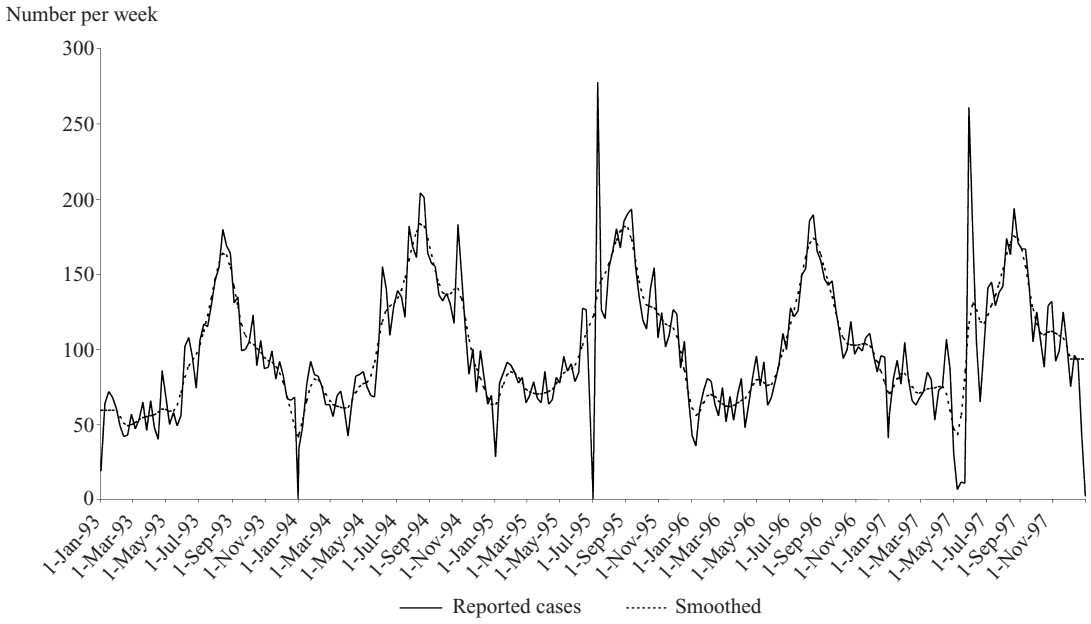

Fig. 4. Sweden, 1993–7.

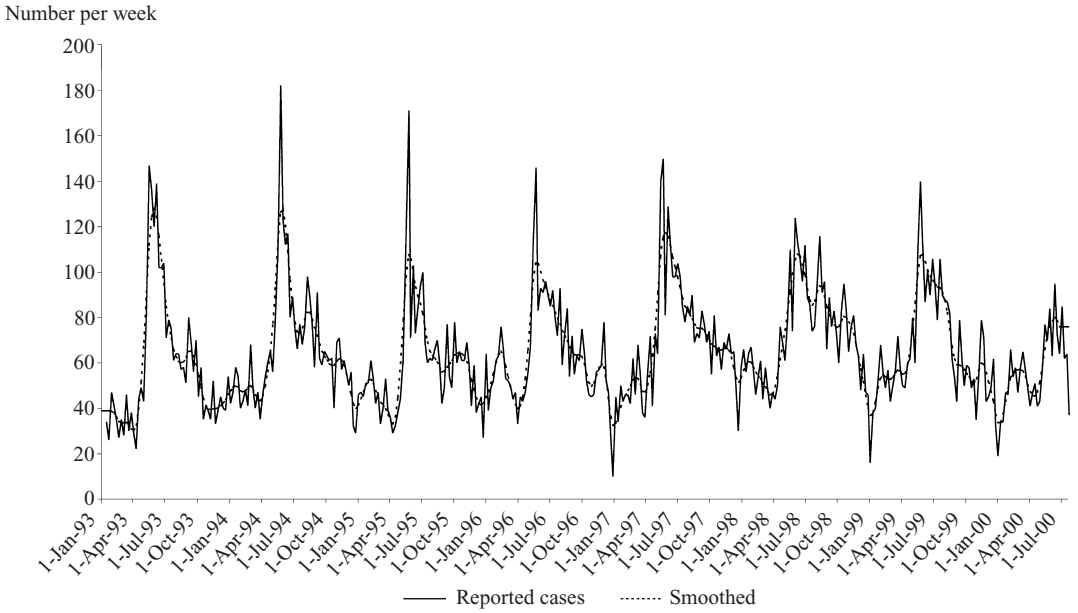

Fig. 5. Wales, 1993–2000.

maximum number of isolates was reported in July every year between 1993 and 1997 (Table 2). In Germany the peak month was less consistent but for the period 1993–7 the overall peak was in August, as was the case in France.

Of the countries where weekly data were available, the peak was most accentuated in Finland, where 14% of the isolates occurred within 2 weeks and 34% within 4 weeks, and least accentuated in New Zealand (Table 3). Within Europe, the seasonal variation was less pronounced in Austria and Scotland compared to Wales and the Nordic countries.

DISCUSSION

We compared the time distribution of campylobacter infections from ten different countries based on available surveillance data in order to better characterize the hitherto neglected seasonal trends, and to

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Table 1. *Week of estimated maximum number of campylobacter isolates in seven European countries, 1989–97*

		Finland		N Zealand	Scotland	Sweden	Wales	
Year	Denmark	S*	R†	R	R	R	S	R
1993	31	—	—	1	25	33	22	23
1994	33	—	—	6	24	33	22	23
1995	35	29	30	49	27	34	21	27
1996	32	30	31	40	27	32	21	23
1997	32	31	32	48	25	34	22	23
1998	31	30	31	—	24	31	23	—
1999	28	29	30	—	28	32	21	—

* S, specimen.
† R, laboratory report.

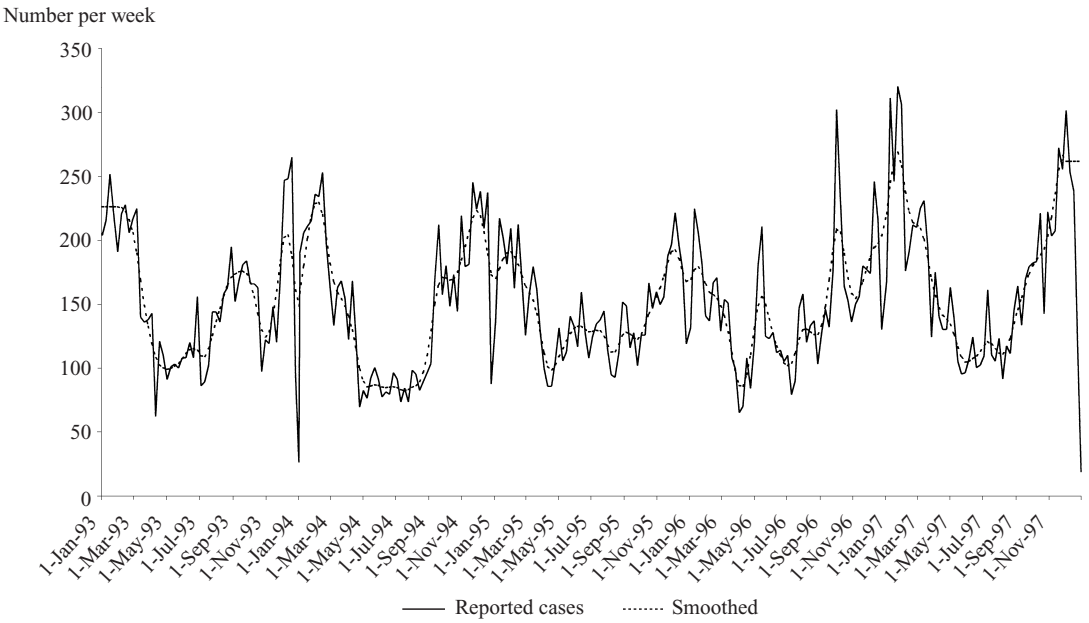

Fig. 6. New Zealand, 1993–7.

Table 2. *Month of maximum number of campylobacter isolates and proportion of isolates occurring in the peak month in Norway and Germany 1993–7*

Year	Norway	Germany
1993	07 (23·3)*	09 (13·1)
1994	07 (21·0)	06 (13·0)
1995	07 (22·7)	09 (15·0)
1996	07 (20·3)	08 (15·0)
1997	07 (19·4)	07 (12·7)

* Percentages in parentheses.

generate hypotheses as to the sources of infection. Surveillance systems differ by country, but although comparisons between countries should be treated with caution, differences in data collection attributable to the different surveillance systems should not affect the time trends described for each country. In the present study, marked seasonal variation, was present in all participating countries.

Seasonal variation has previously been described in several countries both in Europe [15–17, 19] and America [20]. Ideally the best temporal measure would be the date of onset of symptoms of campylobacter infection, but such data from a representative sample of cases are difficult to obtain. The date faeces samples were submitted to laboratories is the next best date to use, but this was available in Finland. Three countries provided the date the specimens were received by investigating laboratories and four provided the date cases were registered with surveillance units. On the

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Table 3. *Proportion of campylobacter isolates falling within a specified number of weeks of the estimated peak*

Time from peak (weeks)	Denmark	Austria	Finland	New Zealand	Scotland	Sweden	Wales	
							Specimen	Report
±1	12	11	14	7	9	10	10	10
±2	18	16	22	11	14	16	16	16
±3	24	21	29	14	18	22	20	22
±4	30	26	34	18	22	28	24	26

evidence of the Welsh experience, the latter date is subject to a delay of usually 1–2 weeks and with more variability, probably due to batching of reports, especially around holiday periods, producing a more fuzzy picture.

The most notable feature of the seasonality is the remarkable consistency year on year of the peak week in several countries. For Wales, peaks in specimen dates occurred at around week 22, which corresponds with the last week of May. In Scotland which has a similar surveillance system to Wales, report week probably is on average a week after specimen date, so that the peak in specimen dates would be in week 25. In Denmark, apart from one year, there was also a consistent peak in specimen dates (around week 32). In Finland the week patients provided specimens peaked in week 30 and laboratories reported results in week 31. In Sweden, which uses the date infection was reported to the surveillance unit, there was again a consistent peak (around week 33). Thus, even allowing for the differences between surveillance systems a consistent season pattern can be detected. Wales has the earliest peak at the end of May, followed about 3 weeks later by Scotland, with Scandinavian countries peaking 5–7 weeks after Scotland. In New Zealand the pattern is significantly different. The peak week is much more variable from year to year and the summer increase is much more prolonged.

The size of the peak as measured by the proportion of all cases falling within ±2 and ±3 weeks of the peak was similar in Wales, Scotland, Austria, Denmark and Sweden, but most prominent in Finland. One factor, which will influence this, is the proportion of cases which are acquired abroad during the holiday season, and this probably varies by country.

Potential hypotheses to explain seasonal variation can be considered in three categories; seasonal variations in human behaviour/life style which expose people to campylobacters, seasonal variations in the prevalence of campylobacter in reservoirs and sources; or a combination of these two.

Known risk factors for campylobacter infection which are likely to be more common during the summer months in temperate regions include animal contact, eating barbecue-prepared meals and drinking untreated water from streams and other natural sources [9]. However, it appears less likely that changes in exposure to these factors on their own can explain the distinct and dramatic increase as seen in Wales, Scotland and the Nordic countries. Variation in occurrence of known campylobacter sources, in particular campylobacter colonization in poultry, has been suggested to be related to the seasonal pattern observed in humans. In a Dutch one-year study of 187 broiler flocks at slaughter, campylobacter carriage was highest (100%) during the period June-September and lowest (50%) in March [21]. A similar study in France also found increased risk of contamination in summer and autumn [22]. In the United States, a similar seasonal variation in carriage-rate was demonstrated in market broilers at retail level [23]. However, in a study in Norway, the proportion of colonized flocks peaked in the autumn, that is after the summer peak in humans [24]. In Denmark a seasonal increase in broilers and humans occurred simultaneously in 1998 [25], but in 1999 the rapid increase in human cases preceded the increased in broilers by about 2 weeks. In the United Kingdom no apparent seasonal variation was found in campylobacter presence in 49 flocks at slaughter between June 1990 and July 1991 [26], but in Lancaster, a study of broilers at one abattoir in one year reported a correlation between carriage rates and environmental variables [27]. However, peaks in campylobacter populations in the small intestine and caeca occurred in June and July which is after the peak in human cases. These and other epidemiological mismatches, such as reduced colonization rates in poultry occurring in Sweden at the time when campylobacter infection rates in humans are increasing [28], indicate a need to reconsider the predominant view that poultry is the main source of human infection throughout the year.

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Fewer studies have been made on seasonal trends in animal sources other than poultry. Seasonal variation has been found in faecal samples from dairy cattle [29] and isolates from the small intestine in lambs at slaughter [30], but no convincing co-variation with the seasonal pattern in humans has been shown. Many wild birds are known to carry campylobacter, but their importance as sources of human infection is unclear. It has been shown that part of the spring-peak in the United Kingdom can be explained by consumption of milk from bottles delivered to the doorstep in which tops have been pecked by birds [13, 14]. However, in a study of carriage rates of *C. jejuni* and *C. coli* in herring gulls at refuge tips, rates were found to be higher in November–December compared to January and April and highest at refuse tips near areas of high population density [31].

Kapperud described a north–south gradient in the seasonality in Norway with a more accentuated peak with increasing latitude [32] and raised the hypothesis that it may be explained by corresponding variations in occurrence of campylobacters in fresh water sources. Isolation rates in contaminated waters have been shown to be highest at temperatures in the range 2–8 °C and lowest at temperatures above 15 °C [33]. A cold climate in northern Norway with water temperatures below 2 °C in the winter and seldom exceeding 15 °C in the summer would account for the accentuated peak compared to southern Norway. However, the studies on seasonal variation in surface waters undertaken so far, both in Norway [33], the United Kingdom [34, 35] and the United States [36] have found highest recovery rates in surface fresh waters in the autumn and winter months and lowest during the spring and summer months. A study of sewage and surface waters in Netherlands in 1992/3 showed no seasonality [37]. The possibility of other, previously unexplored environmental reservoirs linked to differences in climate should therefore be considered.

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