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Risk factors for indigenous campylobacter infection: a Swedish case-control study

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SUMMARY

A case-control study was conducted in western Sweden (Älvsborg County). The aim of the study was to identify any special food items or behaviours associated with an increased risk of contracting campylobacter infection. A total of 101 cases and 198 controls were matched for age, sex and district of residence. The following risk factors or risk behaviours were associated with campylobacter infection: drinking unpasteurized milk (OR 3·56, 95% CI 1·46–8·94), eating chicken (OR 2·29, 95% CI 1·29–4·23), or eating pork with bones (chops OR 2·02, 95% CI 1·17–3·64; loin of pork OR 1·83, 95% CI 1·07–3·12), barbecuing (OR 1·98, 95% CI 1·10–4·34), and living or working on a farm (farm OR 3·06, 95% CI 1·58–6·62, hen/chicken-breeder OR 3·32, 95% CI 1·56–6·78), daily contact with chickens or hens (OR 11·83, 95% CI 3·41–62·03).

INTRODUCTION

Campylobacter

The *Campylobacter* genus is spread all over the world, and is one of the most important bacterial agents of enteric disease. Within the genus are at least 13 different species, of which *C. jejuni* and *C. coli* are the most common in human disease (about 80% consist of *C. jejuni*) [1, 2].

Campylobacteriosis is an acute bacterial disease of variable severity. Common symptoms are diarrhoea, which may be haemorrhagic, abdominal pain and fever. Nausea and vomiting may also occur. Complications such as reactive arthritis [3], meningitis, Guillan-Barré disease [4–7] and possibly miscarriage [8] may also be observed. The infective dose is normally low, about 500 bacteria [9].

In contrast to salmonella, campylobacter does not thrive in foodstuffs or water, owing to its very special habitat requirements (+42 °C, micro-aerophilic). Natural reservoirs of campylobacter are animals, especially waterfowl and chicken, but also cattle, pigs, cats and dogs [5, 10–12], campylobacter is a zoonosis and animals may be infected without showing signs of disease. Birds and cattle are primarily colonized by *C. jejuni* and pigs by *C. coli*.

The source of campylobacter infection is not fully known, especially in sporadic cases of human infection. Different types of foodstuff have been reported as sources of contamination, the most common being chicken [13–15], raw milk [5, 16] and water [2, 13, 14, 17–19]. Less frequently reported is infection following contact with infected farm animals or from person to person spread.

Increasing incidence of campylobacteriosis

An increase in the total number of human infections with campylobacter has been noted in several European countries including Austria, Germany, Denmark, Spain, Northern Ireland, England and Wales [20]. An increase has also been observed in Sweden [21]. It is uncertain whether the rising trends

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in different countries are due to the same or different risk factors. Studies in several countries have attempted to identify the source(s) of contamination [13, 14].

Campylobacter among humans in Sweden

In 1995, 5580 human cases of campylobacteriosis were reported, of which 2551 were caused by indigenous sources. The other cases were infected abroad (mostly tourists). Most of the indigenous cases were sporadic and few outbreaks were reported, except for water-borne outbreaks. Of the reported food-borne outbreaks, chicken and unpasteurized milk were the most common suspected sources.

Campylobacter among chickens in Sweden

In the early 1980s, it was shown that *Campylobacter* spp. were commonly present in chicken in Sweden. Eating insufficiently cooked chicken (< 70 °C) and cross-contamination of other food products during preparation of chicken have been, and still are causes of infection. Studies have shown that the chickens are colonized during their first few weeks of life [12, 22]. Sweden is one of the few countries that, by instituting various programmes, has succeeded in reducing the proportion of campylobacter infected chickens to a level of 10–15% [12]. In view of this success, and in view of the extensive information given to Swedish consumers about the proper ways of handling chicken and the risk of cross-contaminating other food products, one would expect that the number of cases of indigenous infection would decrease. This has not occurred; the number of indigenous campylobacter infections has actually increased.

MATERIALS AND METHODS

This incident case-control study was conducted in the county of Älvsborg in western Sweden during 1995. The county has 450000 inhabitants, including two big cities, seven smaller towns and many rural areas.

Identification of cases

Case definition: indigenous case of campylobacteriosis during 1995 were those who were ill and with stool samples positive for *Campylobacter* spp. and notified under the Communicable Diseases Act. The persons selected were also residents in the county. If several persons from the same household were notified, only the first registered person was interviewed.

During the study period, a major water-borne outbreak of campylobacteriosis occurred, associated with the public water supply in the urban district of Mark, in which over 3000 persons were afflicted. These cases were not included in the study.

Identification of controls

For each case, two controls matched for gender, age group and district of residence were selected. The following criteria led to exclusion:

- any history of earlier, culture-verified campylobacter infection;
- gastro-intestinal symptoms during the previous 2 weeks;
- any trip abroad within the previous 2 weeks.

For the matching criterion 'living in the same geographical area', it was necessary to make an exception in the district of Mark after 29 May, 1995, owing to the above-mentioned, water-borne outbreak. After this date, controls were recruited from another district, which had a similar structure, for example a similar type of social and financial background and a similar type of settlement.

With regard to age, controls were selected if they were within 6 months of the age of the case for cases aged less than 3 years, within 1 year for cases aged 3–20 years and within 2 years for older cases. Young children were matched within a narrower age-band because their eating habits change markedly with increasing age.

With these criteria, lists were drawn from the national population register. Six potential controls were chosen randomly for each case. The closest in age of these six were contacted first, then if any criteria for exclusion were present, or some other reasons were given for not taking part as a control the next nearest in age were asked.

Interview and questions

Cases and controls were interviewed by telephone using a structured questionnaire. This was normally done within 1 month of the onset of symptoms. The questionnaire contained about 80 questions concerning the intake of different food items, food-handling and hygienic procedures in the kitchen, visits to

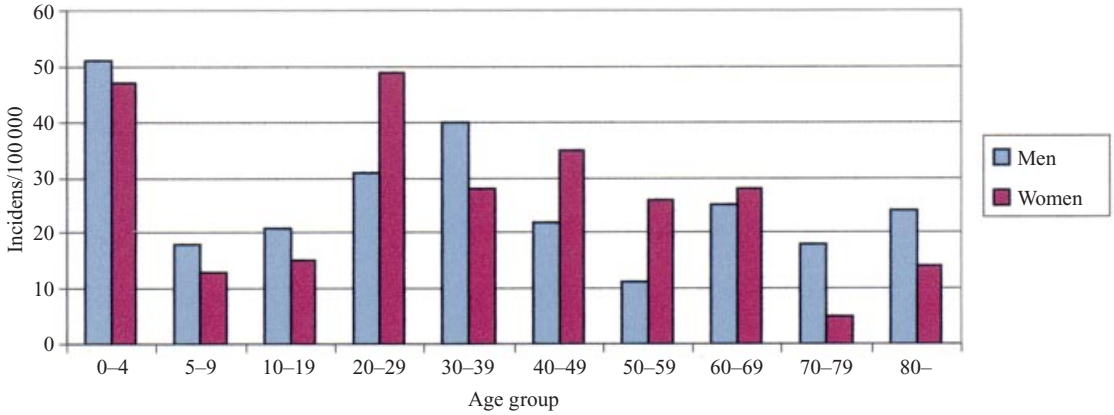

Fig. 1. The incidence by age and sex per 100000 inhabitants of indigenous cases of campylobacteriosis in Älvsborg County during 1995.

restaurants, and contacts with farm animals and pets. Contact with animals was defined as daily direct contact or daily caring for farm animals.

The questions covered the 2 weeks preceding the debut of symptoms or for the controls the 2 weeks preceding the interview. For children under the age of 16, a parent was interviewed. The same questionnaire was used for both cases and controls.

Statistics

The study was designed with controls matched to each individual case. Mantel–Haenszel matched odds ratios (OR), and 95% confidence intervals were used.

RESULTS

Cases and controls

There was a total of 186 cases of indigenous campylobacter infection during 1995 in the county of Älvsborg. Of these, 101 fulfilled the necessary inclusion criteria for the study. Of the 85 cases not included, 66 were reported from the water-borne outbreak mentioned above. Another 19 were excluded because another member of the same family had already been interviewed, because of language difficulties, because of the lack of a definite date of onset or because the report came in too late (more than 1 month after the appearance of symptoms).

Four persons were excluded as controls because they had had gastro-enteritis, and 3 persons because they been abroad in the 2-week period prior to the interview. Another 2 individuals could not participate because they had no telephone, and 5 did not agree to an interview.

Ninety-seven of the cases were matched with 2 controls and 4 cases were matched with 1 control person.

Distribution of cases

The mean age of the 101 cases was 34·1 years (median 33 years, range 1–80). The highest incidence rates were seen in children under 4 years, in women aged 20–29 years and in men aged 30–39 years (Fig. 1). Slightly more than a quarter (27·7%) reported that another family member had fallen ill at the same time, and about 10% reported that one acquaintance had become sick. There were no differences between the genders.

The cases were evenly distributed over the county; 34·5% of the cases lived in a rural setting, 35·6% in a small community and 29·7% in a larger urban area.

Reports of campylobacteriosis occurred over the whole year, but there was a peak in the early autumn, September–October (Fig. 2). Cases from the above mentioned water-borne outbreak are not included.

Behaviour and food products – risk factors

Table 1 shows some risk factors for different types of food and also contact with animals.

Statistically significant risk factors

Consumption of certain foodstuffs (unpasteurized milk, home cooked chicken, fresh chicken and pork) were associated with a higher risk of campylobacter infection. Cases (23·5%) had eaten fresh chicken more often than controls (9·4%). Consumption of ready

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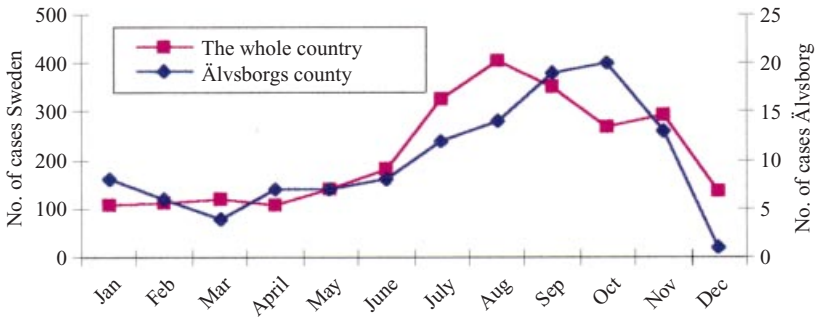

Fig. 2. The distribution of indigenous campylobacter cases per month in Älvsborgs County compared with the whole country during 1995.

Table 1. *Results of some matched cases and control analyses*

Products/food	Cases ($n = 101$)	Control ($n = 198$)	OR	CI 95%	*P*-value
Dairy products					
Unpasteurized milk	17/101	11/198	3·56	1·46–8·94	0·002
Other products from unpasteurized milk	11/101	10/198	2·71	0·89–8·10	0·08
Poultry					
Hen	5/101	5/198	2·0	0·46–8·69	0·43
Chicken	50/101	66/198	2·29	1·29–4·23	0·0038
Chicken liver	6/99	6/198	2·0	0·50–8·58	0·39
Stored grilled chicken	17/101	54/198	0·57	0·27–1·07	0·109
Pork					
Chops	66/99	102/198	2·02	1·17–3·64	0·01
Fillet	33/101	58/198	1·27	0·70–2·26	0·48
Loin of pork	39/101	51/198	1·83	1·07–3·12	0·02
Smoke-cured loin of pork	45/101	84/198	1·26	0·74–2·13	0·44
Ground meat					
Meatballs	76/101	146/198	1·14	0·62–2·21	0·7
Hamburger	48/101	77/197	1·41	0·82–2·48	0·22
Other products					
Chopped meat	19/101	25/198	1·69	0·80–3·66	0·18
Pizza	54/101	85/198	1·69	0·96–3·07	0·07
Pizza salad	36/47	54/74	2·44	0·57–15·06	0·29
Boiled ham	51/101	80/198	1·57	0·87–2·89	0·14
Salami	27/100	40/198	1·63	0·84–3·26	0·15
Barbecue	27/101	31/198	1·98	1·10–4·34	0·02
Work/live/visit					
Farm	30/101	26/198	3·06	1·58–6·62	0·0005
Hen/chicken-breeder	22/101	14/198	3·32	1·56–6·78	0·0008
Animal contact					
Cat	35/101	55/196	1·40	0·76–3·39	0·33
Dog	34/101	50/198	1·42	0·82–2·54	0·21
Pig	7/101	4/198	3·38	0·84–15·48	0·089
Horse	7/101	5/198	2·8	0·76–11·19	0·12
Hen/chicken	18/101	3/198	11·83	3·41–62·03	0·00001

grilled chicken was not associated with a higher risk of campylobacter infection.

Consumption of pork meat with bones was statistically shown to be a risk factor for campylobacter infection, as seen in pork chops and loin of pork.

Barbecuing, particularly chicken, was also shown to carry an increased risk.

There was also a significantly higher risk of contacting campylobacteriosis if one lived on, worked at or frequently visited any type of farm. In poultry

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Table 2. *Treatment of utensils AS between different food products during preparation* (*percentages*)

	Washed with detergent/ dishwasher		Washed only in water		Dried with rag/towel		Not cleaned		Unknown		Changes of utensils	
	Case	Cont.	Case	Cont.	Case	Cont.	Case	Cont.	Case	Cont.	Case	Cont.
Hands	20	21	55	59	4	6	16	10	6	5		
Cutting board	18	18	29	36	13	9	15	15	6	5	20	17
Knives	18	20	40	41	8	5	14	12	6	5	15	17

farms direct contact with hens or chickens constituted a greater risk of contracting campylobacteriosis than just visiting the farm.

Increased but not statistically significant risk

Multivariate analyses showed that pork with bones could be a risk factor independent of living on a farm. Matched analysis showed OR 1·72, 95% CI 0·94–3·15 and unmatched analysis showed OR 1·96, 95% CI 1·16–3·30.

More of the cases than the controls (about 10%) had made their own meatballs and hamburgers.

Eating pizza could also have been a risk behaviour, but was not significant in the statistic analysis.

Other food-handling and types of behaviour

A greater number of controls (30%) than cases (19%), preferred their meat rare or medium. In handling and preparing raw meat, there was no marked difference between the two groups, except as regarded chicken, where cases predominated. Five percent more cases regularly tasted raw, ground meat. In handling utensils in conjunction with preparing meals (for example cutting ham or sausage and lettuce for the same meal) without washing hands in-between, there was an increased risk of contracting the infection (Table 2).

DISCUSSION

The results of this study point to several risk factors that may lead to campylobacteriosis: drinking unpasteurized milk, eating and preparing chicken, eating pork with bones (chops and loin of pork), barbecuing, living on a farm, and having daily contact with chickens or hens.

Several studies have shown that chicken is a common cause of campylobacter infection in humans, a finding that was confirmed in this study. Eating and/or handling chicken is a significant risk factor. In Sweden we anticipated that the number of cases caused by campylobacter would decrease when the frequency of campylobacter in chickens in Sweden declined to 10–15% at slaughter [12], and awareness among the general public of the importance of preparing chicken properly became more widespread. Some wholesalers even offer a 'ready button' (thermometer) in their chickens as an extra precaution. There are no good explanations why the expected decrease of campylobacter infection among humans was not seen; one might be that at the same time, consumption of chicken, especially fresh chicken, may have increased.

In this study we found that those afflicted were more likely to have eaten dishes prepared from fresh chicken. Fresh chicken may carry a higher bacterial count since freezing tends to reduce the number of bacteria. A study from New Zealand [13] also showed that fresh chicken was associated with an increased risk of infection. However, in a Norwegian study [14], an increased risk was found primarily among those who had used frozen chicken, but this may have been due to the small number of persons who had used fresh chicken. Improper handling during the preparation of raw chicken is the most likely cause of cross-contamination, for example using the same cutting board for different food products, or not washing hands after contact with raw chicken.

In this study, it was noted that cases did not wash their hands between handling different food products as often as controls. Most of the persons interviewed, however, stated that they were more careful with hand hygiene when handling chicken, as compared with other food products. Both groups equally reported that they ate well done chicken, which leads to the conclusion that more public information is necessary regarding the risks of cross-contamination during food preparation.

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Consumption of pork with the bone remaining *in situ*, for example pork chop and loin of pork, was also associated with increased risk. Close contact with pigs may also involve a risk, but few persons had contact with pigs. In the former Yugoslavia, there was an increased number of cases during the autumn [23]. The traditional autumn slaughter and subsequent barbecue might have been the cause of several *C. coli* infections [23, 24]. Normally, the most common serotype of *Campylobacter* in humans is *C. jejuni* (80% of the cases). This species is most frequent in chickens. On the other hand, *C. coli* is more common in pigs. The proportions of these species during different seasons in Sweden is not known, since differentiation between *C. jejuni* and *C. coli* is not done on a regular basis. One question is whether or not *C. coli* has become more common in Sweden, or if there are other explanations for the increase in the risk of infection when eating pork meat with the bone remaining. Another possible explanation may be that *C. jejuni* is common in pigs in Sweden. There may be other associated factors since most of those afflicted also live in a rural setting. In the Norwegian study [14] barbecuing was associated with an increased risk of falling ill with campylobacter infection. In this study and the New Zealand study [13], barbecuing chicken was associated with a significant risk. The relative importance of not cooking the chicken thoroughly or of improper handling is not clear.

People living on farms run a higher risk of falling ill with campylobacter infection. They have contact with animals (cows, pigs, chicken and wild animals), they have their own wells and sometimes also access to unpasteurized milk. Here, it is difficult to characterize any isolated risk factor.

Both the New Zealand study [13] and the Norwegian study [14] have shown that surface water may be a risk factor. In this study from Älvsborg County, 8 cases and 7 controls reported having drunk lake or river water. One difference between this study and the Norwegian investigation may be that it is more common to use untreated surface water in Norway. Microbiological studies have shown that surface water might contains campylobacter [25, 26]. Surface water does not seem to play an important role as a risk factor for campylobacteriosis in Älvsborg County, but this may vary from district to district as in the event of hikers drinking surface (river) water in northern Sweden.

The highest peak of illness in this study differs from the general trend of indigenous cases in Sweden. In this study it was noted that most of the cases fell ill in September to October, while the highest level in Sweden is usually in August. There does not seem to be any simple explanation for this difference.

This study has shown that chicken is still the main cause of campylobacter illness in Älvsborg County. Pork meat on the bone may be a new source of infection, but further studies are needed to determine whether or not this is true.

In order to carry out effective tracing of the source of contamination, it is necessary to determine species of campylobacter and further typing.

There is nothing in this study that suggests that ready-to-eat foods are associated with a high risk of campylobacter infection. On the contrary, there is a higher risk for those persons who prepare their own chicken meals. More resources should be invested in teaching proper hygiene in food processing and handling, something that earlier was passed on from generation to generation.

The consequences of the infections we documented in this study were considerable for both the afflicted individuals and the community in terms of loss of production and sick leave. Besides the acute illness caused by campylobacter, there may also be several complications, which may be serious and/or protracted.

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