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A milk-borne campylobacter outbreak following an educational farm visit

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SUMMARY

After a nursery school trip to a dairy farm, 20 (53%) of 38 children and 3 (23%) of 13 adult helpers developed gastrointestinal infection. *Campylobacter jejuni* was isolated from 15 primary cases and from 3 of 9 secondary household cases. A cohort study of the school party found illness to be associated with drinking raw milk (relative risk 5·4, 95% confidence interval 1·4–20·4, $P = 0{\cdot}001$). There was a significant dose response relationship between amount of raw milk consumed and risk of illness (χ^2-test for linear trend 12·1, $P = 0{\cdot}0005$) but not with incubation period, severity of symptoms or duration of illness. All 18 human campylobacter isolates were *C. jejuni* resistotype 02 and either biotype I (number 16) or biotype II (number 2). Campylobacter was also isolated from samples of dairy cattle and bird faeces obtained at the farm but these were of different resisto/biotypes. Educational farm visits have become increasingly popular in recent years and this outbreak illustrates the hazard of exposure to raw milk in this setting.

INTRODUCTION

Raw milk is a well-recognized and important cause of campylobacter outbreaks [1]. It was the common factor in 13 campylobacter outbreaks reported in the UK between 1978–81 and in 14 (61%) of 23 outbreaks in the United States between 1980–2 [2, 3]. Many such outbreaks involve children. In a 10-year survey of communicable diseases in schools in England and Wales (1979–88) milk was implicated in 5 (56%) of 9 campylobacter outbreaks and in a 10-year review of outbreaks in the United States (1981–90), 20 outbreaks associated with drinking raw milk during youth activities were identified [4, 5]. However, such occurrences have become uncommon in recent years. About 10 general campylobacter outbreaks are now reported each year in England and Wales, but only 5 milk-borne outbreaks were reported between 1989–92 [6]. We describe an outbreak of campylobacter which occurred among nursery school children following an educational visit to a dairy farm.

THE OUTBREAK

On 8 April 1994, Cardiff Environmental Services department identified three children with campylobacter infection all of whom attended the same nursery class at a local school. On further enquiry, the school reported other children who had experienced recent gastrointestinal illness. The class had made an educational visit to a nearby working dairy farm on 28

March, shortly before the Easter holiday. There were 51 people in the visiting party including 38 children, 4 staff and 9 parent helpers. The visit lasted 1·5 h and comprised a guided tour of farm activities including viewing horses, calves, new-born lambs and the milking parlour. At the end of the visit, tea or milk with biscuits were consumed in the barn.

METHODS

A complete list of school party members was obtained. Details of any recent illness or illness in household members and of animal contact, soiling with animal faeces, hand washing and food and drink consumption during the farm visit were sought using a structured questionnaire. Adults were asked to complete a self-administered questionnaire whilst parents and helpers completed details for children. Primary cases were defined as any person with diarrhoea or abdominal pain within 10 days of the farm visit or with culture confirmed campylobacter infection. Household members who had not been on the farm visit and who developed diarrhoea or abdominal pain more than 2 days after the household index case were considered to be secondary cases.

Information about other school parties who had visited the farm during the same month was obtained and details of all recent local campylobacter isolates reviewed for possible links with the outbreak.

Data was analysed using Epi Info Version 6 [7]. Relative risks were calculated with Taylor series 95% confidence intervals (CI) and probabilities derived using the χ^2-test with Yates' correction. The relationship between dose and risk of illness, incubation period, severity of symptoms and duration of illness was assessed. Cases were classed as severe if they reported diarrhoea accompanied by blood. Dose-response was analysed by χ^2 test for linear trend (dichotomous variables) or one way analysis of variance (continuous variables) using either the F ratio or Kruskal Wallis test depending on whether the data was normally distributed.

The farm was visited and the route of the farm tour retraced. The water distribution system, milking parlour and dairy were inspected and water samples taken from the farmhouse kitchen tap, dairy tap and farmyard stand pipe. Environmental samples including cattle, horse, sheep and magpie faeces; farmyard dust; straw; and cattle cake (feed) were obtained. Results of routine microbiological milk sample monitoring undertaken by the Ministry of Agriculture,

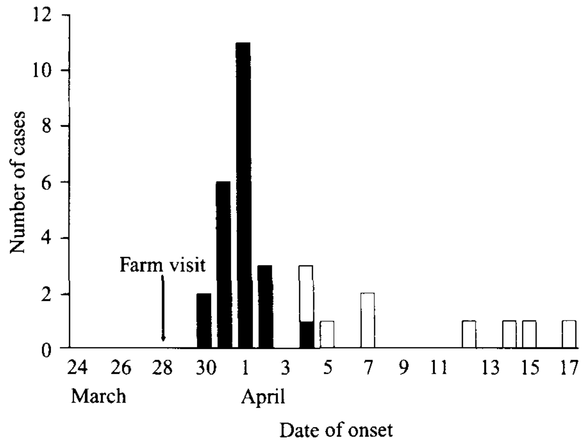

Fig. 1. Campylobacter outbreak after a farm visit, Cardiff, Wales, March–April 1994. Epidemic curve of 23 primary and 9 secondary cases. (■), Primary cases; (□), secondary cases.

Fisheries and Food were reviewed. Faecal specimens were sought from all party members and household contacts with recent illness and examined for campylobacters and other enteric pathogens. All campylobacter isolates were further characterized using biotyping and resistotyping [8].

RESULTS

Epidemiological investigation

Questionnaires were completed for 50 (98%) of 51 persons who visited the farm. Twenty-three persons (46%) met the case definition including 20 (53%) of 38 children, all aged 3 or 4 years, and 3 (23%) of 13 adults. The first case became ill on 30 March and the median incubation period was 4 days (range 2–7 days) (Fig. 1). The predominant symptoms were abdominal pain (96%), diarrhoea (91%) (three or more stools per day), fever (70%) and vomiting (43%). Six cases (26%) reported diarrhoea accompanied by blood. Median duration of illness was 4 days (range 1–14 days) and 15 cases saw their general practitioner though none were admitted to hospital. Illness was significantly associated with drinking cold unpasteurized cow's milk supplied at the farm (relative risk 5·4, 95% CI 1·4–20·4, $P = 0·001$) but not with farm animal or animal faeces contact (Table 1). There was a dose-response relationship between risk of illness and amount of milk consumed (χ^2 test for linear trend 12·1, $P = 0·0005$) (Table 2). Cases drinking larger amounts of milk also had shorter incubation periods and severer symptoms but this relationship did not achieve statistical significance (Table 3). There

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Table 1. *Cohort study. Activity-specific attack rates for farm visit, Cardiff, Wales, March 1994* ($n = 50$*)

	Exposed			Not exposed			
Activity	Case	Total	(%)	Case	Total	(%)	Relative risk (95% CI)
Touching lambs	12	24	50	9	22	41	1·2 (0·6–2·3)
Touching cows	7	18	39	14	29	48	0·8 (0·4–1·6)
Touching horses	11	27	41	9	19	47	0·9 (0·5–1·7)
Biting nails or sucking thumb	6	10	60	17	40	43	1·4 (0·8–2·6)
Drinking milk in tea	3	10	30	20	39	51	0·6 (0·2–1·6)
Drinking cold milk	21	33	64	2	17	12	5·4 (1·4–20·4) $P = 0{\cdot}001$†

* Not all subjects answered every question.
† χ^2 test with Yates' correction.

Table 2. *Quantity of raw milk consumed during farm visit, Cardiff, Wales, March 1994 and risk of illness* ($n = 50$)

Amount drunk	Exposure score	Ill	Not ill	Attack rate (%)	Relative risk
None	0	2	15	11·8	1·0
Part cupful	0·5	3	4	42·9	5·6
Whole cupful	1·0	14	7	66·7	15·0
Extra cupful	2·0	4	1	80·0	30·0

χ^2 test for linear trend 12·1, $P = 0{\cdot}0005$.

Table 3. *Quantity of raw milk consumed during farm visit, Cardiff, Wales, March 1994 and association with severity of symptoms, length of incubation period and duration of illness* ($n = 50$)

Amount drunk	Exposure score	Total ill	Severe symptoms*† (%)	Mean (median) incubation period in days‡	Mean (median) duration of illness in days§
None	0	2	0 (0)	5·0 (5)	4·0 (4)
Part cupful	0·5	3	0 (0)	4·7 (4)	5·0 (6)
Whole cupful	1·0	14	4 (29)	3·6 (4)	4·8 (4)
Extra cupful	2·0	4	2 (50)	3·2 (3)	7·0 (7)

* Diarrhoea accompanied by blood.
† χ^2 test for linear trend 2·6, $P = 0{\cdot}11$.
‡ ANOVA F statistic 2·3, $P = 0{\cdot}11$.
§ Kruskal–Wallis H 6·4, $P = 0{\cdot}35$.

was no relationship between amount of milk consumed and duration of illness.

The 23 cases came from 21 households containing 83 persons. Nine secondary cases occurred among 60 household contacts, a 15% secondary attack rate. Secondary cases occurred between 7 and 20 days after the farm visit (Fig. 1). They included 3 children (aged 8, 9 and 11 years) and 6 adults (4 females, 2 males; mean age 32 years) and involved 5 different households. All secondary cases suffered from both diarrhoea and abdominal pain. All 4 late onset secondary cases (more than 10 days after the epidemic peak) were adults and all came from households with more than 1 secondary case. There was no difference between households with or without secondary transmission in respect of household size (3·8 *vs.* 4·0 persons), median age of index case (3·5 *vs.* 4·0 years) or median age of household contacts (both 30 years).

Two other school parties had visited the farm at around the same time and been offered raw milk but neither school reported any gastrointestinal illness. No raw milk is sold by the farm to the public and there was no excess of campylobacter isolates reported from the locality. The farmer's family members regularly consumed raw milk produced on the farm. The farmer's two young children were both reported to have had recent gastrointestinal illness, but the family declined to supply faecal samples. Two young children at a neighbouring farm had both recently had faecal samples positive for *Cryptosporidium* and one was also positive for campylobacter. One was a frequent visitor to the index farm but was unclear whether she had consumed raw milk.

Environmental investigation

The farm has a herd of 120 dairy cattle and a range of other animals including a few sheep, horses, ducks and geese. Several calves were reported to have been scouring at the time of the school visit, though the school party did not have any direct contact. However, school children did handle some farm animals and ate their refreshments in a barn with ewes and lambs present.

The farm obtains water via the mains water supply, but is the last house at the end of the distribution system. Previous intermittent low mains water pressure was reported with occasional disruption of supply. The corroded water service pipe was renewed by the water company on the day after the farm visit and the water main is scheduled to be refurbished.

Cattle milking takes place in a small traditional milking parlour and the farm produces 9000 litres of milk daily. Cattle teats are dry wiped, the automatic milker applied and milk filtered through a stainless steel filter, kept in a chilled holding tank overnight and collected the following day for onward transportation to a milk processing plant for pasteurization. The milk filter is disinfected by immersion for 12 h in sodium hydroxide solution. Some of the cattle had mastitis but the farmer reported that he discarded all milk from affected cows. Milk is tested daily by the Ministry of Agriculture, Fisheries and Food for total bacterial count and *Escherichia coli*. All routine milk samples were satisfactory. The dairy water supply is drawn from a covered header tank and cattle are fed from a feed hopper. The hopper was holed allowing ingress of birds, and magpies were observed entering on a number of occasions.

Microbiological investigation

Campylobacter jejuni was cultured from 18 human faecal sample from 15 primary cases and 3 secondary cases (including 1 late onset case). Sixteen human isolates (including the 3 secondary cases) were biotype I resistotype 02 and 2 were biotype II resistotype 02. The isolate from the child living on the neighbouring farm was indistinguishable from the outbreak strain. Four of the cattle faeces samples obtained from the farm also yielded *C. jejuni* but these were biotype III resistotype 44 (3 isolates) and biotype II resistotype 00 (1 isolate). One magpie faeces sample also yielded a light growth of campylobacter which did not survive for typing. Over the period of the outbreak, 33 non-outbreak associated human campylobacter cases were diagnosed. Only 7 of these were resistotype 02, 2 *C. jejuni* I, 4 *C. jejuni* I and 1 *C. coli* I. All water samples from the farm were negative for coliforms.

DISCUSSION

The epidemiological evidence implicating raw milk as the vehicle for campylobacter infection in this outbreak is substantial. Consumption of raw milk was the only exposure found to be associated with illness and there was a significant dose-response relationship between risk of illness and the amount of milk consumed. Nearly all cases (20/23) were in children who were more likely to have drunk milk than the adults and may also have been more susceptible to infection due to absence of prior immunity. This may also account for the high attack rate among raw milk drinkers. Persons seldom exposed to raw milk have been shown to be more susceptible to campylobacter infection than regular milk drinkers [9].

The source of the infection is less clear. Milk-borne outbreaks are thought to occur either as a result of faecal contamination of milk [10, 11] or udder excretion of campylobacter by dairy cows [12]. The latter may occur not only in cows with mastitis but also in asymptomatic cows [13]. No gastrointestinal illness was reported by the two school parties who visited the farm earlier in the week (and also consumed raw milk) and the farmer reported discarding all milk from any cows with mastitis, suggesting that a faecal contamination incident may have caused the outbreak. Evidence of cattle infection was found on the farm, although cattle and human isolates were of different bio/resistotype. Several hypotheses can be advanced to explain infection in the cattle herd including spread from other cattle, contamination of the water supply due to low mains pressure or the intriguing possibility of contamination of cattle feed by the birds observed entering the feed hopper.

There are several interesting findings in this outbreak which we wish to highlight. First is the significant relationship between amount of milk consumed and risk of illness, but not with length of incubation period, severity of symptoms or duration of illness. All members of the school party were served with milk direct from the milk chiller and from the same large jug. The milk is therefore likely to have been uniformly contaminated and the infecting dose small. Human volunteer experiments have shown that a dose as small as 500 organisms in milk can produce symptoms [14, 15]. The absence of a clear relationship between dose and incubation period, severity of symptoms or duration of illness may be due to inadequate power to detect an association. Alternatively, it may indicate that the clinical features of campylobacter infection are determined by a number of complex interacting physiological factors including immune status [9, 15, 16].

The second observation of interest is the secondary attack rate. Person-to-person transmission of campylobacter infection is seldom reported even in outbreaks. However, secondary household spread has been reported when the index cases were young children [17, 18]. A review from the United States suggested that secondary household spread may have occurred in 7 (35%) of 20 outbreaks associated with drinking raw milk reported between 1981–90, although no data on attack rate was available [5]. Our data indicate a high secondary household attack rate and suggest that person-to-person transmission may be commoner than previously supposed. Although only 3 secondary cases were microbiologically confirmed, all 9 had characteristic symptoms of diarrhoea and abdominal pain. There was no difference in size or family composition between households with and without secondary transmission. Adult women were most likely to be affected suggesting that assisted toileting of an infected child was a risk factor for spread. Four secondary cases occurred more than 10 days after the epidemic peak, but all were from households with multiple secondary cases and may have been due to transfer of infection between household contacts.

Thirdly, this outbreak shows the potential value of subspecies typing of campylobacter strains [19, 20]. The common bio/resistotype of the majority of the outbreak-related isolates in contrast to the variable bio/resistotype of contemporaneous sporadic isolates provides strong supportive evidence that this was a common source outbreak associated with secondary household spread.

Contaminated milk has long been recognized as an important source of human campylobacter infection and campylobacter has been found in samples of raw milk on public sale in the United Kingdom [21]. During 1980–9, 42 of the campylobacter outbreaks reported to the Communicable Disease Surveillance Centre were associated with milk and of these, 36 (86%) were associated with unpasteurized milk [6]. It has been suggested that the decline in such outbreaks over the past 5 years may be due to more explicit labelling requirements and more rigorous microbiological standards for unpasteurized milk introduced by the United Kingdom government in 1990 [6]. This outbreak shows that even when not offered for sale, raw milk can still pose a hazard to an unsuspecting public, particularly to young children. It is salutary to reflect that had this outbreak been due to another milk-borne pathogen such as verotoxin producing *Escherichia coli* then a case of haemolytic uraemic syndrome, and possibly even a death, might have occurred.

Guidance for farmers who host school parties has been suggested including advice on the importance of hand washing, the provision of adequate hand washing facilities and segregated eating areas [22]. To this should be added a warning to farmers, teachers and youth leaders about the hazards of drinking raw milk. The farmer who sponsored this nursery school trip has now stopped serving raw milk to visitors and no further outbreaks of campylobacter associated with this farm have been reported.

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