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Campylobacter *Enteritis: A Large Outbreak Traced to Commercial Raw Milk*

DAVID N. TAYLOR, MD, *Atlanta;* BRUCE W. PORTER, MPA, *Tucson;* CYNTHIA A. WILLIAMS, BS, *Phoenix;* HILLARY G. MILLER; CHERYL A. BOPP, BS, *and* PAUL A. BLAKE, MD, *Atlanta*

From April 24 to May 11, 1981, an outbreak of approximately 200 cases of Campylobacter jejuni *enteritis occurred in Arizona in persons who drank one brand of unpasteurized milk. Two cohort studies showed that households with members who drank raw milk reported diarrheal illness significantly more frequently than those in which no one drank raw milk (P=.003 and P=.001; relative risk 4.70 and 3.85, respectively). Of 19 serotyped* C jejuni *organisms isolated from persons who drank raw milk from the implicated dairy, 18 were of a single serotype.*

C jejuni *was not detected in the milk or the milk filters cultured a week after the outbreak, but fecal excretion of* Campylobacter *of multiple serotypes was higher in the dairy herd that produced the implicated raw milk (48 percent) than in control herds (16 percent).*

IN GREAT BRITAIN unpasteurized (raw) milk has been described as the major vehicle of transmission in human outbreaks of enteritis caused by *Campylobacter jejuni.*[1] In the United States, cases associated with raw milk ingestion have been reported from California[2] and Colorado.[3] In the past few years it has become apparent that *C jejuni* is an important cause of diarrheal disease and that with appropriate laboratory techniques this pathogen can be readily isolated from fecal specimens. The appropriate methods include a microaerophilic atmosphere, incubation at 42°C (107°F) and a selective medium. Methods to accomplish these growth requirements have recently become commercially available, and many microbiologic laboratories in the United States are now capable of isolating this organism. As a result, in 1981 three outbreaks of *Campylobacter* enteritis that involved consumers of commercially available raw milk were reported to the Centers for Disease Control (CDC) from Oregon (50 cases),[4] Kansas (more than 100 cases)[5] and Arizona (nearly 200 cases). This report describes the Arizona outbreak

From the Enteric Bacteriology and Epidemiology Branch, Center for Infectious Diseases, Centers for Disease Control, US Public Health Service, US Department of Health and Human Services, Atlanta; the Pima County Health Department, Tucson, and the Arizona State Department of Health Services, Phoenix.

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Reprint requests to: David N. Taylor, MD, Enteric Bacteriology & Epidemiology Branch, Center for Infectious Diseases, Centers for Disease Control, 1600 Clifton Road, Atlanta, GA 30333.

and shows the usefulness of *Campylobacter* serotyping in the investigation of such outbreaks.

Methods

Epidemiologic Investigation

On May 4, 1981, a physician reported to the Pima County (Arizona) Health Department that an 82-year-old woman admitted to hospital in Tucson with bacteremia and enteritis due to *C jejuni* habitually drank five glasses of raw milk a day. To locate additional recent cases of diarrheal disease, the health department contacted physicians in the Tucson area who were likely to see patients with an acute gastrointestinal illness and all hospital epidemiologists and laboratories in Tucson. In this way, 39 cases were found. A case was defined as diarrhea (three or more loose stools per day for more than one day) or two of four other enteric symptoms (bloody diarrhea, fever, abdominal pain or vomiting) in a person who drank raw milk from dairy A in the week before onset of illness. On May 8 a public announcement was made that notified the community of a possible outbreak of enteritis and asked that persons with a current or recent gastrointestinal illness call the health department. Persons who called were questioned about demographic data; personal and family histories of diarrheal disease; recent consumption of raw milk, untreated water or poorly cooked meats, and whether they had had contact with ill or well pets and other domestic or wild animals. Persons with an illness suggesting *Campylobacter* enteritis were asked to submit a stool specimen to their physician or to the health department.

To determine whether those who drank raw milk had more enteritis from late April to early May than those who did not drink raw milk, we interviewed two groups of persons known to include many raw milk drinkers. The first group were members of a cooperative grocery store (COOP) and the second were recent patients of a chiropractor who advocated raw milk ingestion for many of his patients and who also owned a chain of health food stores in Tucson. The COOP and the health food stores sold both pasteurized and unpasteurized milk. We obtained names and telephone numbers of active COOP members from weekly work assignment rosters used at the store and randomly selected every fifth household from the weekly rosters for the previous three months. Similarly, from the chiropractor we randomly selected every fifth name from a roster of patients seen for the first time during the three months before the outbreak. On May 10 we conducted a telephone survey of 106 households that belonged to the COOP and 95 households of patients seen by the chiropractor. About 80 percent of the originally selected households were successfully reached. We did not encounter an overlap between these two groups, but some of the households that we surveyed had already reported illness to the health department. Each household was asked what brand of milk they drank and the age, sex, milk consumption and illness history during the last two weeks for each member of the family. The cohort studies were analyzed by a two-tailed Fisher's exact test.

Laboratory Investigation

Rectal swabs or fecal specimens from humans were transported on Cary-Blair medium to the Arizona Department of Health Services laboratory or the Enteric Diseases Branch laboratory, CDC, for isolation of *C jejuni* by methods already described.[6] Rectal swabs were taken from cattle at the implicated dairy and from cattle from three nearby dairy herds (dairies B, C and D). These specimens were cultured for *Campylobacter* by the Arizona Department of Health Services laboratory. Human and animal *Campylobacter* isolates were transported to CDC on Wang's medium.[7] Serotyping was done at CDC by the method of Penner and Hennessy.[8]

A total of 16 milk samples from containers with pull dates indicating that the milk was on sale during the outbreak were first plated directly onto Campy-BAP medium and were also filtered through a 0.65 μm filter (Millipore Corporation), and the filtrate was plated onto Campy-BAP. The milk and filtrates were inoculated into two enrichment broths (Oosterom's medium and Bryner's medium). The enrichment broths were incubated for 24 hours at 42°C and then subcultured to Campy-BAP. Sections of four milk filters used on May 8, 9 and 10 to filter milk from the implicated herd were placed into 250 ml of a bile-containing enrichment medium (Oosterom's). They were incubated for 24 hours at 42°C and then subcultured from enrichment medium to Campy-BAP.

Results

Outbreak Investigation

Using the case definition outlined earlier, we identified 190 cases in 88 families distributed

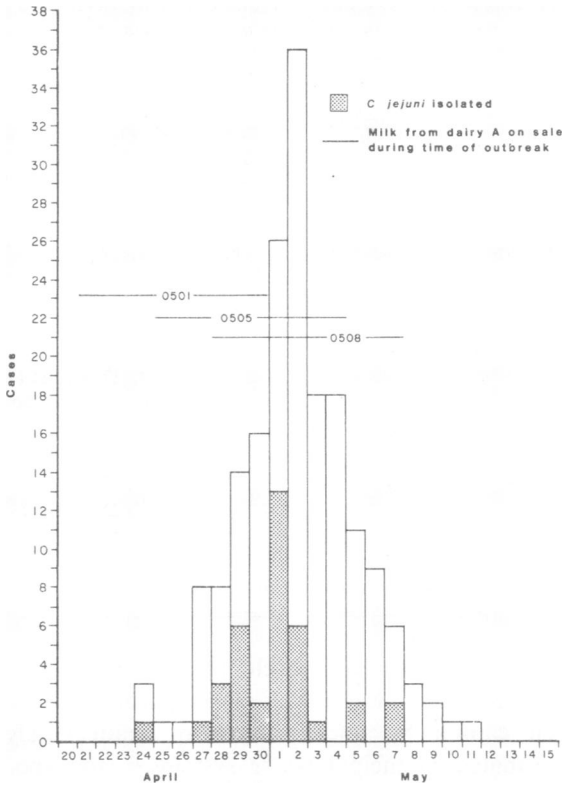

Figure 1.—Cases of enteritis associated with raw milk, Tucson, Arizona, April 20 through May 15, 1981.

C jejuni = *Campylobacter jejuni*

throughout Tucson and Pima County. Single rectal swabs were obtained from 58 of these ill persons, and *C jejuni* was isolated from 37 (64 percent). About half of the ill persons were male, and the median age was 23 (range, 6 months to 85 years). The highest attack rate in drinkers of dairy A milk in the affected families occurred in persons 20 to 29 years old (40 [95 percent] reported illness) and the lowest attack rate occurred in adults 40 years old or older (33 [63 percent] reported illness).

In the 88 families, 190 (79 percent) of 241 persons who drank raw milk from dairy A but none of the 77 persons who did not drink raw milk became ill with an illness having all the features of *Campylobacter* infection. In the group that drank raw milk, 70 percent of 57 persons who drank less than a glass of milk, 86 percent of 70 who drank one to two glasses and 82 percent of 91 who drank more than two glasses per day reported illness (23 unknown). The difference between drinking less than one glass and drinking one or more glasses was significant ($P = .03$), but the linear trend was not.

Those who met the case definition reported the following symptoms: diarrhea (90 percent), abdominal pain (84 percent), fever (69 percent), headache (69 percent), nausea (64 percent), bloody diarrhea (29 percent) and vomiting (20 percent). Onsets of illness occurred between April 24 and May 11 and peaked on May 1 and 2 (Figure 1). Voluntary pasteurization of milk from dairy A began on May 8.

Besides the index case, the only other person known to have been admitted to hospital was a 22-year-old man who a year earlier had had a splenectomy following trauma. This otherwise healthy young man drank one glass of milk three days before an illness characterized by high fever followed by explosive diarrhea. Cultures of blood and stool specimens done soon after hospital admission grew *C jejuni*. He recovered quickly after a short course of intravenously given fluids and antibiotics.

Illness was also reported in seven families in Mesa, a small town near the dairy, where the raw milk was also distributed. In these families 18 persons ranging in age from 1 to 76 years met the case definition. The peak date of onset of symptoms in this group was May 3. *C jejuni* was isolated from two of five rectal swabs taken from ill persons.

In the COOP survey, 6 of 12 households in which raw milk from dairy A was drunk reported one or more household members with diarrheal illness, while only 10 (11 percent) of 94 households in which raw milk from dairy A was not drunk reported illness ($P = .003$, relative risk = 4.7 [95 percent confidence interval (CI) between 1.79 and 12.33]). Similarly in the health food survey, 9 of 18 households in which raw milk was drunk reported one or more household members with diarrheal illness, while 10 (13 percent) of 77 households who did not drink raw milk reported illness ($P = .001$, relative risk = 3.85 [95 percent CI between 1.68 and 8.81]).

Investigation of the Dairy

Dairy A has been in operation for more than 20 years. At the time of the investigation the dairy was milking 200 cows and producing about 10,000 gal of milk a week. Of the 10,000 gal, 7,000 gal are pasteurized and distributed in Phoenix and 3,000 gal are not pasteurized, of which 2,000 gal are distributed in Tucson and the rest in the area around the dairy. The health food chain buys an estimated 1,000 gal a week

(200 gal per store) and the COOP grocery buys about 120 gal a week. Raw milk going to Tucson is produced on Friday and Monday and shipped on the following days. The raw milk that was on the shelves during the outbreak was distributed on April 21, 25 and 28. Milk is dated ten days after delivery; therefore, the milk delivered on April 21 was labeled "0501," milk delivered on April 25 "0505" and milk delivered April 28 "0508." Discussions with the dairyman indicated that there had been no changes in his dairy practices and there had not been an increase in mastitis or enteritis in his milking herd.

Laboratory Investigation

Campylobacter was not isolated from ten milk specimens obtained from the homes of ill persons and from the stores with milk on the shelf with the suspected pull dates, nor was *Campylobacter* found on cultures from five milk filters obtained on May 8, 9 and 10 from dairy A.

A sample of 42 healthy cattle from dairy A and 50 cattle each from three nearby dairy herds was tested for fecal excretion of *C jejuni*. *Campylobacter* was isolated from 20 (48 percent) of 42 cows at dairy A and from 22 percent, 16 percent and 12 percent of the cows sampled at the other three dairies.

Of 19 *C jejuni* isolates from persons who drank raw milk from the implicated dairy, 18 (95 percent) were one serotype (PEN-2), but multiple serotypes were isolated from the dairy herds. In the sample from the implicated herd, PEN-7 was the predominant serotype, whereas PEN-2 was not recovered (Table 1).

TABLE 1.—Campylobacter *Isolations and Serotypes From Feces From Humans and Cows in a Raw Milk-Associated Outbreak in Arizona, April Through May 1981*

Source	Campylobacter *Isolation* No. Tested	Campylobacter *Isolation* No. Positive	*Serotypes** No. Tested	*Serotypes** Serotype (No. Positive)
Human				
Tucson	58	37	17	2(16), 19 (1)
Mesa	5	2	2	2(2)
Cattle				
Dairy A ...	42	20	20	7(11), 16/13(2) 16(2), 37(1), 4(1) 7/36(1), (2 untypeable)
Dairy B ...	50	11	3	11(3)
Dairy C ...	50	8	7	1/8(2), 7/4(1), 7(2), 7/25(1), 2(1)
Dairy D ...	50	6	2	11(1), 7(1)

*Described in Penner and Hennessy.[8]

Discussion

Because *C jejuni* is harbored by a large and diverse group of animals, human infection may be acquired from many sources. Animals with which man has frequent contact such as dogs, cats, poultry, cattle, sheep and swine can all excrete this organism.[9] Studies in zoos and of trapped wild animals have indicated a high rate of fecal carriage among migratory waterfowl[10] and hoofed wild animals.[11] Transmission from pets has occurred during contact with these animals.[12] Transmission from other domestic animals occurs indirectly through consuming inadequately cooked meats or unpasteurized dairy products. Outbreaks or cases have been noted to occur after drinking raw milk as in this outbreak, and after eating raw chicken,[13] hamburger,[14] clams and processed turkey. Infection can also occur after drinking contaminated water. Large waterborne outbreaks have been caused by unchlorinated or inadequately chlorinated municipal water systems,[15] and sporadic cases have been traced to drinking untreated surface water.[16]

Foods with high fat content such as milk, cheese, chocolate and hamburger are especially efficient vehicles for the transmission of *Salmonella*[17]; this type of vehicle may be just as important in the transmission of *Campylobacter*. Two volunteers became ill after ingesting *C jejuni* in milk; one volunteer became ill after ingesting only 500 organisms.[18]

Because we lack sensitive techniques for isolating *Campylobacter* from milk, we do not know how often or to what degree commercial milk is contaminated before it is pasteurized. Milk is probably contaminated from cow feces at the time of milking, but bovine mastitis is another possible source of contamination.[19]

Investigation at the implicated dairy did not disclose improper milking techniques or dairy practices. Fecal contamination cannot be totally eliminated even by meticulous dairy hygiene practices, and *C jejuni* can survive for weeks in milk kept at 4°C (39.2°F),[20] so pasteurization appears to be the only way to completely eliminate the risk of milk-borne *Campylobacter* disease. In England and Wales many milk-borne outbreaks have occurred as a result of faulty pasteurization, while the outbreaks in the United States have

occurred because of people's insistence on drinking unpasteurized milk. The increase in the number of milk-borne disease outbreaks due to *Campylobacter* appears to be the result of increased surveillance and awareness of the epidemiology of *Campylobacter,* though an increase in the consumption of raw milk in the United States may be a contributing factor.

Since the outbreak had begun to wane before pasteurization or public notification occurred, other factors must have initiated its decline. The outbreak may have been limited in part by the exhaustion of susceptible persons among those who drank raw milk. At the time of the investigation only 1,100 gal of raw milk were sold per week in Tucson. From the survey data we know that raw milk drinkers usually bought the same brand of milk each week, and that they consumed an average of ½ gal per week. We found little difference in attack rates between those who said they drank large quantities and those who drank small quantities. The absence of a pronounced dose effect supports Robinson's theory that a small dose in milk can cause illness.[18] Another factor that may have contributed to the end of the outbreak is that the milk in subsequent deliveries may have been less heavily contaminated.

Serotyping identified a common strain in humans and supported the epidemiologic evidence that the cases of *Campylobacter* enteritis that occurred in two separate locations in Arizona were derived from a single source. The epidemic strain may have been missed in the sampling of the implicated dairy herd because it came from a single cow from which specimens were not cultured, the infection was transient and no longer present when the cultures were done or the epidemic strain may not have been present in feces at all but derived from another source such as mastitis. Further work is necessary to determine how *Campylobacter* is introduced into a dairy herd and then contaminates milk.

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