Campers' Diarrhea Outbreak Traced to Water-Sewage Link

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Synopsis

From June through September 1979, diarrheal illness occurred in an estimated 1,850 persons who had camped at a private campground in Arizona. Illness occurred more frequently among campers at that campground than among those in the adjacent State park ($P < 0.0001$). The same well served both the private and the State campgrounds as the source of drinking water, but that water was distributed to the two campgrounds through separate lines. Illness was significantly associated with drinking water at the campsite ($P < 0.0001$), drinking larger quantities of campsite water ($P < 0.001$), and camping on the southwest side of the campground ($P < 0.001$).

Samples of the water collected from the system during January through June contained no coliform bacteria. However, all those samples had been collected from the State park only. Of the 11 water samples submitted for bacteriological analyses during the summer, 3 had high levels of bacteria. Excavation of the water system uncovered a direct cross connection between the potable water system and a sewage-effluent irrigation system.

This outbreak calls attention to the importance of designing, maintaining, and monitoring potable water systems properly, especially those proximate to wastewater re-use systems.

DIARRHEAL ILLNESSES were reported in June 1979 to public health agencies in California and Arizona by campers who had visited a private campground adjacent to an Arizona State park on the Colorado River (fig. 1). By August, reports of the illness had been received from eight groups of campers. An initial investigation by the Arizona Department of Health Services—questionnaires were mailed, June through August 1979, to the 65 persons among those groups who had reported diarrheal illness—implicated the drinking water at individual campsites as the cause.

Of the 53 persons who had consumed water at a campsite, 51 (96.2 percent) indicated that they had had diarrhea during or following their visit to the campground, compared with 3 of 12 (25 percent) who did not drink the water ($P<0.0001$). No further surveys could be done because the campers' mailing addresses had not been recorded routinely. Although the results of tests on the drinking water did not exceed the standards for coliform, an order to boil the water was issued September 26.

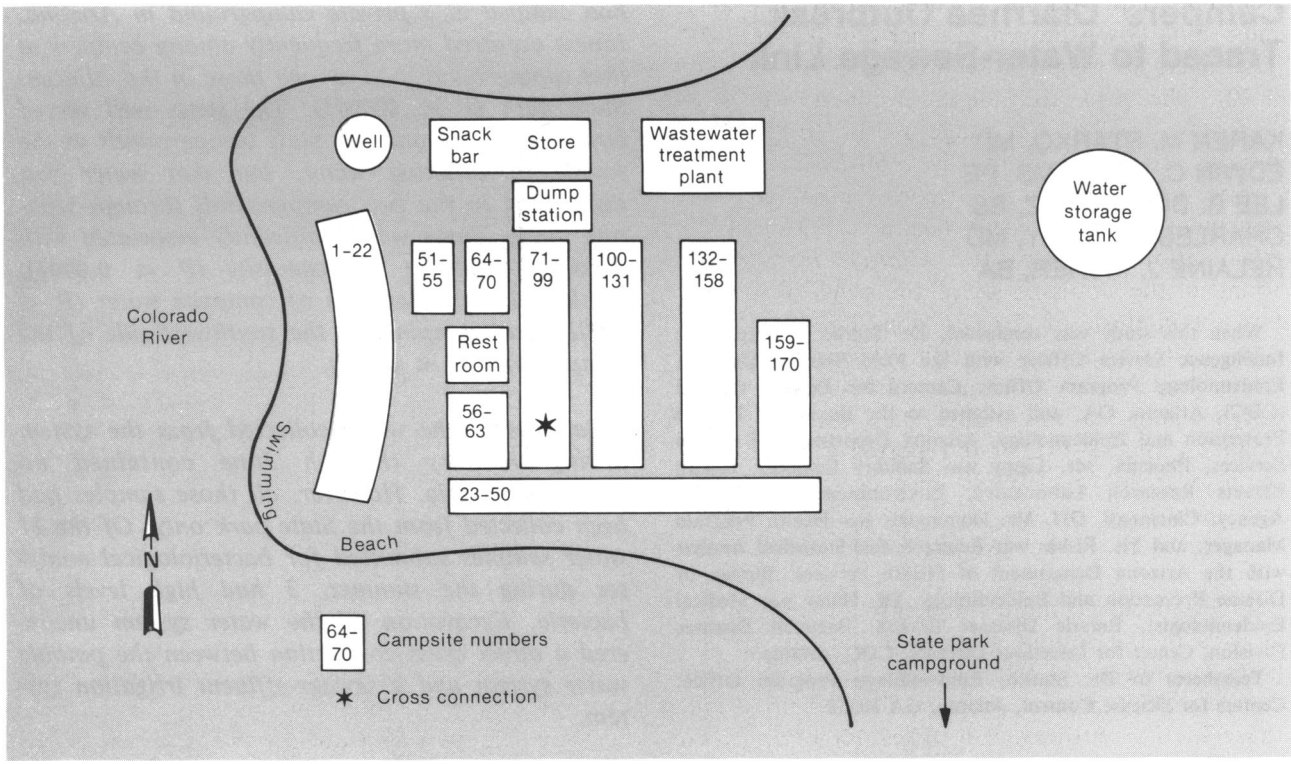
Just before the Labor Day weekend in 1979, the Arizona Department of Health Services stressed upon managers of the two campgrounds, State and private, the need to record addresses of visiting campers so that a different set of campers could be surveyed in a study aimed at (*a*) confirming the source of the outbreak, (*b*) estimating its size, and (*c*) assuring that sufficient measures had been taken to end it. We report on that study subsequently.

Methods

This investigation included two retrospective surveys and an examination of the water system.

• The study groups—all the persons who had camped at least one night at the private and the State park campgrounds during Labor Day week-

Figure 1. Site of outbreak of diarrheal illness among campers at private campground in Arizona, 1979



end, August 31 through September 3, 1979—were surveyed by telephone. The persons contacted were asked to give information on members of their groups. If they could not, other members of the group were contacted directly.

- Interviewers used a standard questionnaire and asked for demographic, illness, and exposure data. Camp-associated illness was defined as diarrhea that occurred during the period campers stayed at the campgrounds or the 3 weeks after.
- Results of routine testing on samples of the water were reviewed and the water system evaluated.
- The 25 groups who had camped at the private campground during consecutive periods in November 1979 were surveyed by mail as a followup to assure that the outbreak had ended.

Statistical significance was determined with the use of the two-tailed Fischer's exact test, chi square for linear trend, and the two-tailed Student's *t* test.

Results

Telephone numbers, which were obtained from the camp's log or the telephone directory, were available for 59 of the 179 groups who registered at the private campground during the Labor Day weekend. Of those 59 groups, 44 (162 persons) were surveyed. Telephone numbers were available for 20 of the 42 groups who registered at the State park campground during that period; 14 groups (75 persons) were surveyed. (The 15th group was contacted, but the members refused to participate.) Of the 162 campers at the private campground, 57 (35.2 percent) experienced diarrhea while camping or during the 3 weeks after, compared with only 6 of the 75 campers (8 percent) at the State park campground ($P<0.0001$). The remainder of this analysis is confined, therefore, to data on persons who camped at the private campground.

Onset of the 57 cases of diarrheal illness occurred September 1-15, 1979 (fig. 2). Maximum and minimum incubation periods were calculated based on the day of onset and the days of arrival at and departure from the campground. The mean ± one standard deviation (X ± SD) minimum incubation period was 2.8 ± 2.6 days (range = 1-12 days), and the X ± SD maximum incubation period was 5.1 ± 3.1 days (range = 1-15 days).

The cases of illness were characterized by watery diarrhea (54 of 55), abdominal cramps (52 of 55), anorexia (52 of 55), fatigue (39 of 50), nausea (37 of 55), chills (32 of 49), fever or feverishness (34 of 56), headache (21 of 47), abdominal gas (22 of

47), vomiting (21 of 56), and bloody diarrhea (9 of 51). The ill persons experienced an average maximum nine bowel movements per day (range 2–25). The average weight loss was 5 pounds (range 0–20). The X ± SD length of illness was 21 ± 19.9 days (median 14, range 1–70). Of the 57 ill persons, 19 (33.3 percent) saw a physician.

One group of nine persons submitted stool specimens to their local health department for examination for parasites. *Giardia lamblia* was found in the stools of six of the seven ill persons, but not in those of the two non-ill persons (P = 0.08). All six ill persons with *G. lamblia* in their stools had watery diarrhea, abdominal cramps, fatigue, anorexia, and chills. They lost a median 9 pounds (range 3–17). Four reported a documented temperature of ≥ 101° F. Five of the 6 illnesses had incubation periods of 1 or 2 days, and the campers were ill an average of 59 days (range 50–63).

Illness occurred more frequently among campers at sites in the southwest side of the campground (sites numbered 1–99), where 46 of the 102 campers (45.1 percent) became ill, compared with those in the northeast side (sites 100–170), where 11 of 60 campers (18.3 percent) became ill ($P<0.001$). Campers who became ill resided at the campsite longer (average = 3.1 days) than those who did not become ill (average = 2.6 days) ($P<0.05$).

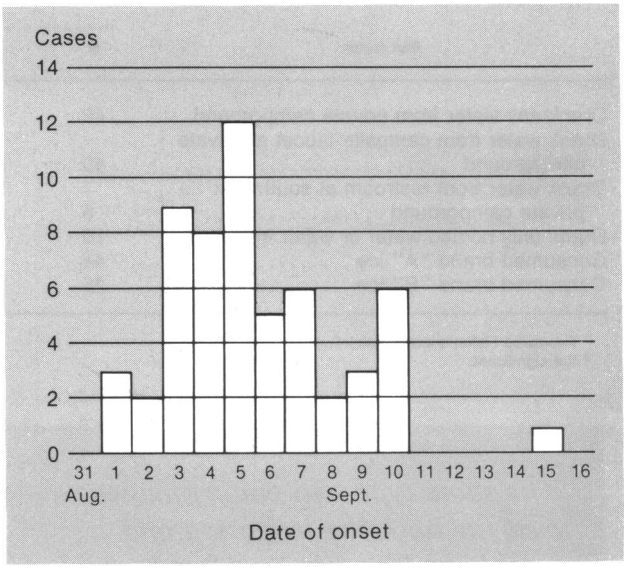
Diarrheal illness was associated significantly with a camper's consuming water from any faucet on the private campground and from the faucets at the individual campsite (table). Further, a person's average daily consumption of water from the campsite faucet while camping and before becoming ill was directly related to illness, as follows:

Campsite water consumed daily	*Percent of campers who became ill*[1]
0 glasses	19.8 (17 of 86)
1–3 glasses	28.2 (11 of 39)
4–5 glasses	70.6 (12 of 17)
more than 5 glasses	85.0 (17 of 20)

[1]$P<0.001$.

Persons who drank water from the faucet in the restroom located in the southwest campground had a higher incidence of illness than persons who did not (P = 0.05). Campers who drank only commercially bottled water or water transported from their homes also had a low incidence of illness ($P<0.05$).

Figure 2. Cases of diarrheal illness among campers at a private campground in Arizona, August 31 - September 16, 1979, by date of onset



All persons who became ill denied having drunk the water from the following sources: the restroom in the store, the spigot outside the store, the public campground, and the river. Exposures not statistically associated with illness were drinking the water from the snack bar, getting the face wet while waterskiing, getting the face wet while swimming at the campground beach, eating food purchased at the campground store, eating at the campground snack bar, or consuming brand "A" ice. Although consumption of brand "B" ice was associated significantly with illness ($P<0.01$), fewer than one-half the number of persons who became ill consumed this ice, which was prepackaged in a commercial plant that used city water.

Evaluation of the water and wastewater systems at the private campground revealed that, because the system had been developed over a period of 6 years by four owners, records for documenting the design and maintenance facts were not available. Water was obtained from a shallow well adjacent to the Colorado River, chlorinated, and pumped to a storage tank on the hill behind the campground (fig. 1). Separate distribution networks carried the water to the State park and the private campgrounds. Each campground had its own sewage system. The wastewater system at the private campground disposed of all sewage-plant effluent through subsurface bubbler irrigators situated adjacent to campsite shrubs and trees. The same type and color pipe was used for both the irrigation and potable water systems. Moreover, both sys-

Incidence of diarrheal illness among campers at a private campground on Labor Day weekend, 1979, by exposure to selected risk factors

Risk factor	Exposed			Not exposed			P value[1]
	Ill	Total	Incidence	Ill	Total	Incidence	
Drank any water from private campground	42	86	48.8	15	76	19.7	<0.001
Drank water from campsite faucet at private campground	40	76	52.6	17	86	19.8	<0.0001
Drank water from restroom at southwest private campground	5	7	71.4	52	155	33.5	0.05
Drank only bottled water or water from home	10	47	21.3	47	115	40.9	<0.05
Consumed brand "A" ice	44	114	38.6	13	48	27.1	NS[2]
Consumed brand "B" ice	26	50	52.0	31	112	27.7	<0.01

[1] Two-tailed Fisher's exact test.
[2] Not significant.

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tems operated under pressure, and the pressure applied to the sewage irrigation system by a pump was greater than that of the water system. At some time a supplemental drip irrigation system using potable water was added to the private campground water system. This system used fittings that permitted a steady dripping of water into pits sculptured around the bases of trees and shrubs. Those fittings, however, were submerged in the water that pooled in the pits, creating a potential cross connection if subatmospheric pressure occurred in the water system.

The review of reports on drinking water samples that had been analyzed for bacteria, January 1 through June 18, 1979, showed that all the samples—none of which grew coliform organisms—had been collected from the State park side of the water system. However after June 18, drinking water samples from the private campground side had been collected, and 3 of the 11 tested, late June through August, showed bacterial growth. Those findings were reported as "too numerous to count" or "confluent growth." The samples were from the hose at the boat ramp, the faucet at campsite 50, and the faucet at campsite 58. The hose and faucet at campsite 50 showed no bacterial growth when resampled 2 weeks later. Sites that showed no bacterial growth at any occasion were the well, faucets at campsites 22 and 55, the dump station, and the residence near the water storage tank.

When fluorescein dye was introduced into the sewage treatment plant (with the system operating under normal conditions), the water from the drinking water faucets in the southwest area of the campground became intensely dye-colored. Subsequent excavation of the system uncovered a direct cross connection between a drinking water pipe and a sewage effluent irrigation pipe at campsite 89. That defect was eliminated in October 1979.

A followup mail survey was conducted of the 63 persons who had camped at the private campground in November 1979, and 51 responded (81 percent). Of those, only one reported having had a diarrheal illness within 3 weeks after camping.

To estimate the number of persons who became ill as a result of this outbreak, the incidence of illness in the State park campground (8 percent)—as determined in the survey among persons who had camped over the Labor Day weekend—was subtracted from the incidence in the private campground (35.2 percent). The excess incidence was applied to the number of registered campers from June 1, the date of encampment for the first camper who reported illness, through September. During that period, 6,837 persons visited the campground, of whom 1,850 are estimated to have become ill.

Discussion

Between 1971 and 1979, the average number of outbreaks per year of waterborne diseases reported to the Environmental Protection Agency (EPA) or

the Centers for Disease Control (CDC) was 29. Between 1980 and 1984, the number had grown to 41 per year. Between 1971 and 1983, the number of persons who were affected annually, on the average, was 8,211 (range = 1,650–20,905).

This outbreak illustrates that contaminated water in a small recreational area can cause a sizable number of illnesses. In the United States, semipublic water systems (systems in institutions, industries, camps, parks, hotels, or service stations that may be used by the general public) were responsible for 46.8 percent of the 427 waterborne disease outbreaks reported between 1971 and 1983 (*1*). Actually, that number may be an underestimate of the extent of the problem. Some outbreaks may go unrecognized because persons who become ill while traveling return home to different health jurisdictions. It is difficult, therefore, for any one local health agency to recognize an outbreak or measure its magnitude.

As with 79 percent of the 20,905 outbreak-related cases of waterborne disease reported to CDC or EPA in 1983, the pathogen(s) responsible for this outbreak was not identified. (In 1983, *G. lamblia* was the agent most commonly identified as the cause of illness in 2,207 persons.) Based on the mean minimum incubation period of 2.8 days and the mean maximum incubation period of 5.1 days, we can speculate what pathogens may have caused this outbreak: *Escherichia coli* (incubation period 6–36 hours), *Salmonella* (6–48 hours), *Shigella* (12–48 hours), *Campylobacter* (2–10 days), *Yersinia enterocolitica* (3–7 days), *G. lamblia* (4–12 days), Norwalk group (16–72 hours), and rotavirus (24–72 hours). However, the typical clinical syndrome of our cases does not fit the characteristics of any single agent among these. We suspect that the illness was caused initially by multiple pathogens, either viral or bacterial, and that simultaneous *G. lamblia* infections were important in extending the duration of illness.

Defects in water distribution systems have caused outbreaks in the past (*1–3*). This outbreak demonstrates further that attention must be paid to the design and maintenance of drinking water systems as well as to the sources of the water. A critical deficiency in this campground water system was created when identical piping materials were used for both the potable water and the sewage-effluent irrigation systems. That construction, coupled with the absence of plumbing diagrams and the use of inexperienced maintenance personnel, led to the existence of an unhealthful cross connection.

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Lessons can be learned from the mistakes made in collecting the water samples for bacteriological analyses and in interpreting test results. First, before the outbreak, the samples were collected from the State park only. Those samples were not representative of the entire system because the system had two distinct distribution lines: one for the private campground and the other for the State park campground. Second, after the outbreak began, water samples that were specific to the system either did not reveal any contamination or were so heavily contaminated they were disregarded as having been inappropriately collected or stored. Had these samples been investigated properly, the source of contamination might have been identified sooner.

References

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