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Contaminated roof-collected rainwater as a possible cause of an outbreak of salmonellosis*

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SUMMARY

Roof-collected rainwater is a common water source in subtropical regions and has not been associated with human illness. In Trinidad, the West Indies, a church group, attending a rural camp, developed gastrointestinal illness, caused by *Salmonella arechevalata*. This rare serotype was isolated from stool specimens of campers, foods eaten at the camp, and a water tap, which was supplied by a storage tank of roof-collected rainwater. The surface of the roof, used as water catchment, was covered with bird faeces. It is postulated that rainwater, falling on the roof, washed off animal excrement which contained *S. arechevalata* and led to the outbreak of salmonellosis through camper ingestion of contaminated food and water.

INTRODUCTION

Catchment of rainwater is a common water source in the West Indies and other subtropical areas. Although waterborne outbreaks caused by a variety of agents including *Salmonella* have been reported (Horwitz, Hughes & Craun, 1976), rainwater collected for consumption has not been associated with human illness. We recently investigated an outbreak of gastrointestinal illness in which the agent was a rare *Salmonella* serotype, *S. arechevalata*, and the probable vehicle, roof-collected rainwater.

BACKGROUND

From 10–15 April 1976, 73 children, 5–19 years of age, and 15 adult supervisors attended a camp in rural northern Trinidad. On 14 April, 48 of these children and adults attending the camp were referred to a general hospital because of diarrhoea, headache, fever and vomiting.

The camp is operated by a religious organization and holds 2- to 7-day sessions for various congregations for religious and recreational activities. Each group provides its own kitchen staff and food supplies.

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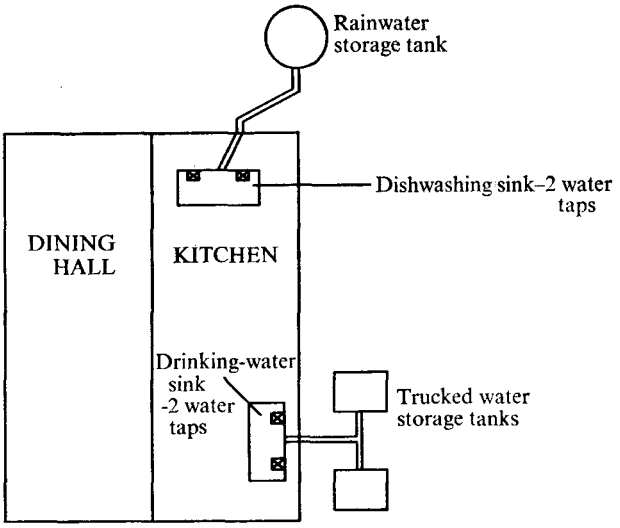

Fig. 1. Diagram of kitchen/dining facility with water tanks and taps.

Toilet facilities consist of pit privies located 50 m from the dining facility, with drainage down a ravine. At the time of the outbreak, water for the camp came from two sources: (*a*) water from municipal wells, which was chlorinated, trucked to the camp and stored in several tanks, serving the kitchen/dining hall and camp director's residence; (*b*) rainwater collected in gutters draining the kitchen/dining hall roof and stored without chlorination in a single water tank. It had been raining intermittently daily before and during the outbreak. The kitchen had four water taps: two at the rear wall fed by a tank in which trucked water was stored and two at the dishwashing sink (see Fig. 1) fed by the tank storing non-chlorinated water.

METHODS

Epidemiological: The 48 ill persons were interviewed at the hospital on 14 April. Using an all inclusive list of campers and supervisors attending the camp between 10–15 April, we conducted a second interview in late April to obtain information from all persons attending the camp during the epidemic period. In both interviews, we recorded the following information: name, age, sex, address, symptoms, time and date of onset of symptoms, food consumed in the 48 hours before symptom onset and duration of illness. Rectal swabs or stool specimens were collected from all surveyed persons.

Illness was defined as having diarrhoea or abdominal cramps at any time between April 10 and 15. A case was defined as a person who had attended the camp during 10–15 April and had been either ill *or* had a stool culture positive for *S. archevalata*.

Bacteriological: Rectal swabs and stool specimens were screened for *Salmonella*, *Shigella*, and pathogenic vibrios by standard methods (Edwards & Ewing, 1972 and Feeley & Balows, 1974). *Salmonella* cultures were serotyped at the Salmonella

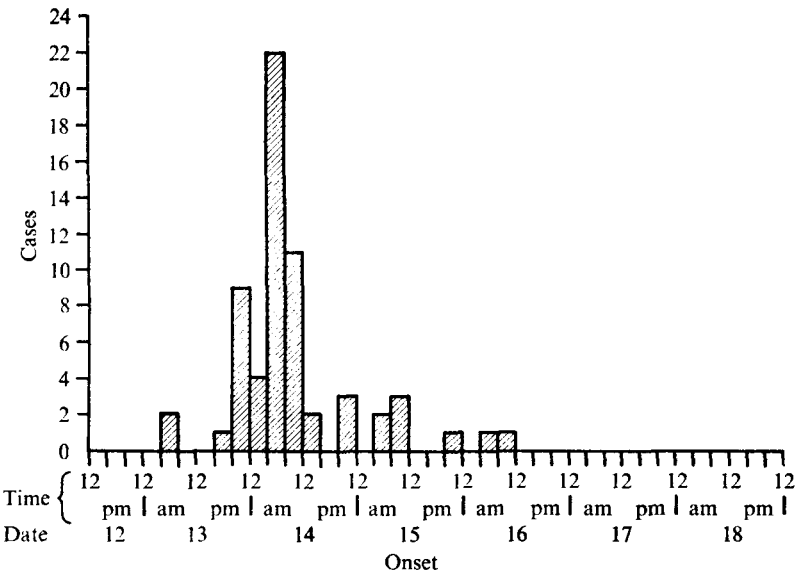

Fig. 2. Sixty-two confirmed and suspected cases of *Salmonella arechevalata* gastroenteritis, by onset, Arouca, Trinidad, April 1976.

and Shigella Reference Laboratory, London, U.K., and the Enteric Section Bureau of Laboratories, Center for Disease Control, Atlanta, Georgia, U.S.A.

Food samples were analysed by standard techniques (U.S.F.D.A., 1976). Environmental surfaces from the kitchen were swabbed with a sterile cotton-tipped applicator, premoistened with Cary-Blair medium and then enriched with selenite broth. Tap water was collected after it was allowed to flow for two minutes and the taps were subsequently flamed. Water samples were analysed for total and faecal coliforms by the tube dilution technique (A.P.H., 1976).

Animal investigations: To investigate the hypothesis that animals may have contaminated the rainwater, local birds, rodents and reptiles were caught and their intestinal contents cultured. Fresh bird excrement was collected from the roof of the kitchen/dining hall building and cultured.

RESULTS

Epidemiological: Information was obtained by questionnaire from 83 camp attendees (94% response). Sixty-three were or had been ill, and 20 remained without symptoms; the attack rate was 76%. Onset of illness was clustered within a 24 h period beginning in the afternoon of 13 April (Fig. 2). The mean duration of illness was 65 h (range: 6–96 h). The illness was characterized by diarrhoea (80% of infected persons), abdominal cramps (59%), headache (52%) and subjective feelings of weakness (52%) and fever (51%). Twelve campers with dehydration required hospitalization for intravenous fluid therapy.

S. arechevalata was isolated from stools or rectal swabs from 56 persons attending the camp. The culture results for persons with symptoms and without symptoms

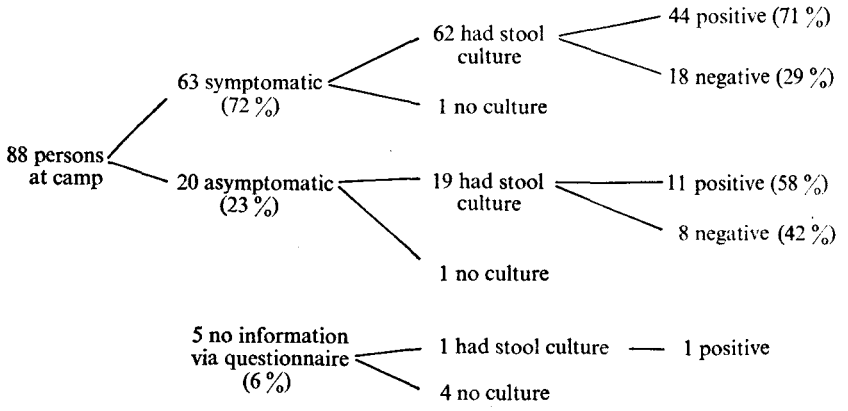

Fig. 3. Clinical illness and culture results in 88 persons attending camp, Trinidad, 10–15 April 1976. 'Positive culture' refers to isolation of the epidemic organism *S. arechevalata*.

are shown in Fig. 3. Seventy-one per cent of persons with symptoms (44/62) had cultures positive for *S. arechevalata* and 58 % of symptomless persons (11/19) had positive cultures.

Sixty-three persons were clinically ill and 11 persons were symptomless but culture positive, resulting in a total of 74 cases. The total attack rate was 89 % (74/83). Attack rates did not differ for the sexes. However, the attack rate for campers under 20 was 96 % (65/68), while for those 20 years and over, it was 60 % (9/15) ($P < 0{\cdot}001$).

Food preference lists obtained from the campers did not incriminate a particular food item as the vehicle of infection. All campers had drunk water and were unsure of its source.

The resident camp director and the three other members of his family lived in a separate home, cooked their own food, and used only trucked municipal water. They had not eaten camp food nor drunk from the camp dining facility during 10–15 April but were in their home on the camp grounds. None of the family became ill, and *S. arechevalata* was not isolated from their stool cultures.

The woman who usually supervised the kitchen for all groups using the camp had been on leave from camp during 10–15 April. No food she had prepared or handled had been used by the group in the outbreak. She, in turn, had eaten no food prepared or handled by the group. However, this woman drank water from both sets of kitchen taps regularly and had *S. arechevalata* isolated from her stool on two examinations after her return to the camp (and after the group of persons involved in the outbreak had departed the camp for their homes). Her positive cultures were taken on 15 April and 5 May. She was not ill at any time before, during or after the outbreak.

Food bacteriology: Specimens of 22 raw and prepared food items from recent meals were taken from the kitchen on 14 April for bacteriological analysis. Two items, 'saltfish buljol' (an uncooked mixture of flaked fish, onions, tomatoes and seasoning) and stewed pigeon peas, although not incriminated in the food preference questioning, yielded the epidemic organism on culture.

Environmental evaluation: Twenty-five swab specimens were taken from kitchen surfaces (refrigerator shelves, sink drains, food preparation counters, cutting blades, wooden chopping boards, etc.). No salmonellas or other pathogenic organisms were isolated.

Water bacteriology: Specimens were obtained from all kitchen taps and water storage tanks. On 27 April, neither water specimens from the 2 kitchen taps supplied by the tank containing trucked water nor the storage tank itself yielded faecal coliforms or salmonellas on culture. Water samples from the two kitchen taps fed by the roof-collected rainwater were positive for *S. arechevalata* on two occasions (27 April and 4 May). Roof-collected rainwater in the storage tank itself was not sampled until 6 May; at that time it contained an unacceptable level of faecal coliforms, but no salmonellas were isolated.

Animal investigations: All 105 bird fecal specimens, 16 bird rectal swabs, two lizard fecal specimens, two rat fecal specimens and three mannicou (opossum) intestinal contents were negative for salmonellas. One specimen of toad faeces yielded an F group *Salmonella* on culture.

DISCUSSION

This outbreak of gastrointestinal illness was caused by a group B *Salmonella*, serotype *arechevalata*. The Salmonella and Shigella Reference Laboratory (Public Health Laboratory Service, U.K.) reported this serotype in only 14 persons in the United Kingdom during 1951–1975. *S. arechevalata* has not previously been isolated from human food or water.*

The organism was found in two food items served at the camp on 12 April. One (buljol) had been soaked in water and then mixed and eaten uncooked, and the other had been diluted with tap water after cooking (pigeon peas). The organism was also isolated from a kitchen water tap that was supplied by roof-collected rainwater.

No sewerage lines crossed or passed near the pipe that led from the rainwater storage tank to the kitchen taps. The pipe was intact throughout its length, and the strength of flow suggested that it was not obstructed.

Trees were located along the sides and back of the kitchen/dining hall building. Their branches extended over the roof and harboured a large number of birds (mostly mocking birds, house wrens and doves) and their nests. The roof surface was covered with dried and fresh bird droppings.

A hypothesis that might explain the outbreak is that rainwater falling on the roof washed off animal excrement (probably avian) which contained *S. arechevalata*. It is well established that animals and birds, both domestic and wild, are frequent carriers of *Salmonella* (Osborne, 1976; Morse & Duncan, 1974; Cornelius, 1969; Quevado *et al.* 1973). This contaminated water had been used for drinking and food preparation and had infected persons ingesting it. The high attack rate of 89 % suggests that the infecting vehicle was water or a food item which virtually everyone at the camp had eaten.

* Communication, Dr B. Rowe, 21 July, 1976

Additional data incriminating raw water as the principal vehicle of infection is provided by the camp kitchen supervisor, who was infected with *S. arechevalata* although she had not eaten any of the same food as the camp group but did drink the tap water regularly. However, our inability to isolate this organism from the storage tank itself or from local animal life or their excrement makes our explanation only speculative.

The difference in attack rates between persons under 20 years and those 20 years and older may be due to the under-20 group's having consumed more contaminated food or water in keeping with a difference in tastes, appetites and amount of exercise. In addition, *Salmonella* has been shown to have a higher incidence in persons under 20 years of age, particularly infants under 1 year, but also in the 5–9 year age group (Center for Disease Control, 1976).

The camp director was advised to stop using rainwater for drinking and to drain the rainwater storage tank, clean it and rinse it with a concentrated chlorinated solution. The storage tank was to be filled in the future with the same trucked water as the other tanks and fitted with a secure cover. After this was done, two water specimens each from the kitchen tap and the tank were found to be free of *Salmonella* and other faecal coliforms.

Roof collection of rainwater is usually done individually for each dwelling, and disease transmitted by rainwater within a household is less likely to be reported than disease affecting several households. In addition, most localities where it is necessary to collect rainwater for human consumption are relatively dry and are sparsely forested, and overhanging tree limbs laden with birds and their nests rare. These factors may account for the lack of previous reports of outbreaks caused by roof-collected rainwater.

This outbreak and its hypothesized vehicle and mechanism suggest that roof-collected rainwater may become contaminated and produce human disease. Chlorination should be considered when rainwater is used for human consumption. If trees with nesting birds overhang roof catchments, they should be cut back or removed. Many people throughout the world obtain their drinking water in this manner; therefore, public health authorities should be alerted to its potential hazard and the need to document further the extent of the problem.

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