

A Large Community Outbreak of Salmonellosis Caused by Intentional Contamination of Restaurant Salad Bars

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Context.—This large outbreak of foodborne disease highlights the challenge of investigating outbreaks caused by intentional contamination and demonstrates the vulnerability of self-service foods to intentional contamination.

Objective.—To investigate a large community outbreak of *Salmonella* Typhimurium infections.

Design.—Epidemiologic investigation of patients with *Salmonella* gastroenteritis and possible exposures in The Dalles, Oregon. Cohort and case-control investigations were conducted among groups of restaurant patrons and employees to identify exposures associated with illness.

Setting.—A community in Oregon. Outbreak period was September and October 1984.

Patients.—A total of 751 persons with *Salmonella* gastroenteritis associated with eating or working at area restaurants. Most patients were identified through passive surveillance; active surveillance was conducted for selected groups. A case was defined either by clinical criteria or by a stool culture yielding *S* Typhimurium.

Results.—The outbreak occurred in 2 waves, September 9 through 18 and September 19 through October 10. Most cases were associated with 10 restaurants, and epidemiologic studies of customers at 4 restaurants and of employees at all 10 restaurants implicated eating from salad bars as the major risk factor for infection. Eight (80%) of 10 affected restaurants compared with only 3 (11%) of the 28 other restaurants in The Dalles operated salad bars (relative risk, 7.5; 95% confidence interval, 2.4-22.7; $P < .001$). The implicated food items on the salad bars differed from one restaurant to another. The investigation did not identify any water supply, food item, supplier, or distributor common to all affected restaurants, nor were employees exposed to any single common source. In some instances, infected employees may have contributed to the spread of illness by inadvertently contaminating foods. However, no evidence was found linking ill employees to initiation of the outbreak. Errors in food rotation and inadequate refrigeration on ice-chilled salad bars may have facilitated growth of the *S* Typhimurium but could not have caused the outbreak. A subsequent criminal investigation revealed that members of a religious commune had deliberately contaminated the salad bars. An *S* Typhimurium strain found in a laboratory at the commune was indistinguishable from the outbreak strain.

Conclusions.—This outbreak of salmonellosis was caused by intentional contamination of restaurant salad bars by members of a religious commune.

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OUTBREAKS of foodborne infection are caused by foods that are intrinsically contaminated or that become contaminated during harvest, processing, or preparation. It is generally assumed that such contamination events occur inadvertently; intentional contamination with a biologic agent is rarely suspected or reported.^{1,2}

On September 17, 1984, the Wasco-Sherman Public Health Department in Oregon began to receive reports of persons ill with gastroenteritis who had eaten at either of 2 restaurants in The Dalles, Ore, several days before symptom onset. Local and state public health officials confirmed an outbreak of *Salmonella* Typhimurium associated with the 2 restaurants and then noted an abrupt increase in reports of gastroenteritis the following week among persons who had eaten or worked at other restaurants in The Dalles. Because many patients reported eating food from salad bars, the local health department closed all salad bars in the town on September 25, 1984, and the Oregon Health Division requested assistance from the Centers for Disease Control (CDC) for further evaluation and control of the outbreak.

The epidemiologic investigation identified the vehicles of transmission as foods on multiple self-service salad bars and probable times when contamination occurred. Common mechanisms by which salad bars could have become contaminated were excluded. A subsequent criminal investigation found that members of a nearby religious commune had intentionally contaminated the salad bars on multiple occasions.

BACKGROUND

The Dalles, population 10 500 (1980 census), is the county seat of Wasco County, population 21 000, a region of orchards and wheat ranches. Located near the Columbia River on Interstate 84, The Dalles is a frequent stop for travel-

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ers. Two independent water systems serve The Dalles: a smaller system supplied by a well and a larger system that serves most restaurants and uses surface water augmented by well water during the summer. From 1980 through 1983, only 16 isolates of salmonellae were reported by the local health department; 8 isolates were *S Typhimurium*. No case of salmonellosis was reported in the first 8 months of 1984.

In 1981, followers of Bhagwan Shree Rajneesh purchased a large ranch in Wasco County to build a new international headquarters for the Indian guru.³⁻⁵ Construction of the commune was controversial from its inception; cultural values and land-use issues were the major areas of conflict. Part of the ranch was incorporated as the city of Rajneeshpuram, but the charter was challenged in the courts, effectively limiting new construction. Commune members believed that the outcome of the November 6, 1984, elections for Wasco County commissioners would have an important impact on further land-use decisions.³⁻⁵

METHODS

Case Definition

A case was defined as an illness with diarrhea and at least 3 of the following symptoms: fever, chills, headache, nausea, vomiting, abdominal pain, or bloody stools, or by a stool culture yielding *S Typhimurium*. A patient was considered to have had an outbreak-associated case if onset of symptoms or collection of an *S Typhimurium*-positive stool specimen occurred between September 9 and October 10, 1984, and the patient resided in or had visited The Dalles during that interval. A case in a person who ate at a restaurant in The Dalles within 7 days before the onset of illness or who worked at a restaurant in The Dalles was considered to be a restaurant-associated case. A single restaurant exposure (SRE) denotes that only 1 restaurant exposure occurred during the 7 days before onset of symptoms. A case was considered to be secondary if it occurred in an individual who had not eaten or worked at a restaurant in The Dalles in the 7 days before onset of symptoms, but was exposed to a case patient during that interval.

The 38 restaurants in The Dalles were divided into 3 groups based on the number of culture-confirmed case customers with an SRE. Group 1 restaurants were definitely affected and had at least 3 culture-confirmed case customers with an SRE. Group 2 restaurants were possibly affected and had at least 1 case customer with an SRE, but fewer than 3 culture-confirmed case customers with an SRE.

Group 3 restaurants were not affected and had no case customers with an SRE.

Outbreak Investigation

Cases were identified through passive surveillance. Press releases encouraged reporting by case patients and health care professionals. We interviewed possible case patients about symptoms and risk factors and obtained comprehensive food histories for restaurant meals eaten during the 3-day period before onset of symptoms. Case customers with an SRE were asked to identify all other persons with whom they had eaten at the restaurant. Histories were obtained from persons so identified, and those who were not ill and reported no other restaurant exposure served as controls for food-specific case-control analyses. Potentially exposed cohorts, such as banquet participants and take-out food patrons, were identified from restaurant records, and attempts were made to interview these persons.

Employees of group 1 restaurants were interviewed twice. During the outbreak, investigators interviewed employees when restaurant involvement was first suspected. In October 1984, immediately following the outbreak, all employees were asked to complete a self-administered questionnaire. Work schedules were obtained from review of time cards, interviews with restaurant managers, and review of insurance claims for workers' compensation.

Laboratory Methods

Stool specimens were submitted to local and regional laboratories to be cultured for enteric pathogens. Employees from group 1 restaurants were required to submit a stool sample to be cultured or be excluded from work. Ill employees with a single negative stool specimen were required to submit a second stool specimen for confirmation before returning to work. The Oregon Public Health Laboratory and the Washington Public Health Laboratory serotyped human *Salmonella* isolates and performed antibiotic-susceptibility testing on a sample of isolates. A representative sample of outbreak isolates, based on epidemiologic criteria, was submitted to CDC for further biochemical characterization and plasmid profile analysis with restriction endonuclease digestion, using *Hind*III.^{6,7} The Oregon Public Health Laboratory also submitted *S Typhimurium* isolates from other outbreaks and sporadically occurring cases, collected during 1984 and thought to be unrelated to the outbreak, to CDC for comparison with the outbreak strain by plasmid analysis. The Oregon Department of Agriculture and the

Oregon Public Health Laboratory cultured suspected foods.

The Dalles outbreak strain was compared with human isolates included in 2 national surveys of salmonellae in 1979 and 1980 and in 1984 and 1985.^{8,9} To identify a possible animal reservoir, CDC characterized all available veterinary isolates of *S Typhimurium* identified between October 1, 1984, and September 30, 1985, by the US Department of Agriculture National Veterinary Services Laboratory in Ames, Iowa.

Environmental Studies

Local health department sanitarians and US Food and Drug Administration representatives investigated the distributors and original suppliers of foods used in group 1 restaurants. All group 1 restaurants were inspected by sanitarians. Records of the city water system were reviewed for the month of September 1984. Tap water samples were collected during the outbreak from restaurants for analysis. Temperatures maintained by ice-chilled salad bars were evaluated.

Statistical Analysis

Food exposure data were analyzed separately by restaurant and by date of onset of illness at the 2 restaurants that had recurrent outbreaks. Univariate analyses were performed and odds ratios (ORs) with 95% confidence intervals (CIs) were calculated using the Epi Info computer program Version 6.03.¹⁰ Foods found to be associated with illness in univariate analyses were analyzed using a stepwise logistic regression model. Univariate analyses of employee survey data were performed, and relative risks (RRs) with 95% CIs were calculated using Epi Info.

Criminal Investigations

Managers of affected restaurants were interviewed about unusual incidents or disgruntled employees. Suspicious events were referred to the Oregon State Police and the Wasco County sheriff for investigation. The Federal Bureau of Investigation (FBI) reviewed local investigation efforts. Following the completion of the epidemiologic investigation and after the collapse of the Rajneesh commune, the FBI, with technical assistance from the Oregon Public Health Laboratory, investigated clinic and laboratory facilities in Rajneeshpuram. A sample of *S Typhimurium* seized from the Rajneesh Medical Center on October 2, 1985, was compared with the outbreak strain.

RESULTS

We identified 751 patients who met the case definition; 441 patients (59%)

were female and 310 (41%) were male. Patients ranged in age from newborn to 87 years (median, 33 years). At least 45 persons (6%) were hospitalized; no fatalities were reported. The epidemic curve was biphasic (Figure 1). The first wave of illness, September 9 through 18, peaked on September 15, and the second wave, September 19 through October 10, peaked on September 24. Of 674 patients (90%) with known date of symptom onset, 88 (13%) became ill during the first wave and 586 (87%) became ill during the second wave. There were 692 restaurant-associated cases (92%), 11 secondary cases (1%), and 48 cases (6%) with incomplete information on restaurant exposure (Table). Among persons with restaurant-associated cases, 101 (15%) were employees and 591 (85%) were customers. There were 519 SRE case customers and 72 case customers with multiple restaurant exposures.

Ten of the 38 restaurants in The Dalles were definitely affected (group 1) (Table). Two group 1 restaurants had culture-confirmed SRE case customers in the early wave (restaurants A and B), but all 10 were affected in the late wave (Figure 2). These 10 restaurants were associated with 494 SRE case customers (95%), 69 case customers with multiple restaurant exposures (96%), and 91 case employees (90%). Twelve restaurants were possibly affected (group 2), accounting for 25 SRE case customers (5%). Three case customers with multiple restaurant exposures (4%) had reported eating at a group 2 restaurant but not at a group 1 restaurant. Sixteen restaurants were not affected (group 3). There was no geographic clustering of affected restaurants, but dates of exposure for culture-confirmed cases were clustered (Figure 2). Restaurant involvement in the outbreak was associated with operating a salad bar. Eight (80%) of 10 group 1 restaurants compared with only 3 (11%) of the 28 other restaurants in The Dalles operated salad bars (RR, 7.5; 95% CI, 2.4-22.7; $P < .001$).

Investigation of Illness Among Customers

The 4 group 1 restaurants where food-specific exposure rates were determined accounted for 283 (55%) of all 494 SRE case customers. Customer illness in all 4 restaurants was associated with eating from the salad bar. Restaurant A was affected during both waves of the outbreak, but different items on the salad bar were implicated for each wave. During the first wave, eating either macaroni, potato, four-bean, or pea salads was associated with illness (OR, 35.8; 95% CI, 4.2-1563.4; $P = .01$), and

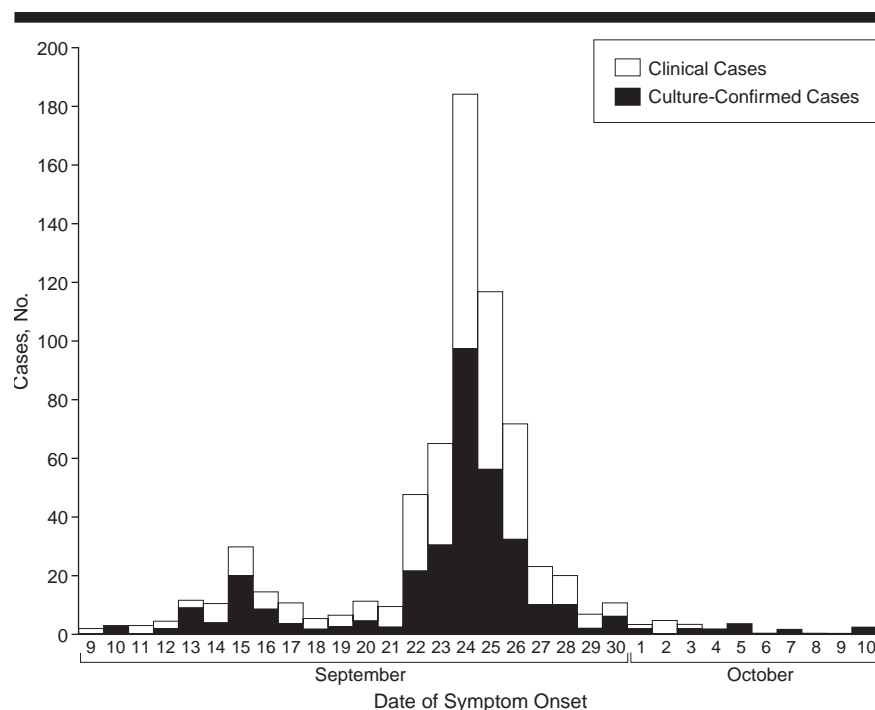


Figure 1.—Reported cases of *Salmonella* Typhimurium gastroenteritis by date of symptom onset for 674 cases (89.8%) with known date of onset, The Dalles, Ore, 1984.

Outbreak-Associated Cases of *Salmonella* Gastroenteritis by Group and Exposure Location

Group and Exposure Location	Culture-Confirmed Cases, No. (% of Total)	Clinical Cases, No. (% of Total)	Total Cases, No. (% of Total)
Case employees			
Group 1 restaurants (n=10)	74 (9.9)	17 (2.3)	91 (12.1)
Group 2 restaurants (n=12)	4 (0.5)	5 (0.7)	9 (1.2)
Group 3 restaurants (n=16)	1 (0.1)	0 (0.0)	1 (0.1)
Case customers			
Group 1 restaurants (n=10)	227 (30.2)	267 (35.6)	494 (65.8)
Group 2 restaurants (n=12)	6 (0.8)	19 (2.5)	25 (3.3)
Group 3 restaurants (n=16)	0 (0.0)	0 (0.0)	0 (0.0)
Multiple restaurant exposures*	32 (4.3)	40 (5.3)	72 (9.6)
Secondary cases	4 (0.5)	7 (0.9)	11 (1.5)
Cases with incomplete information	40 (5.3)	8 (1.1)	48 (6.4)
Total	388 (51.7)	363 (48.3)	751 (100.0)

*A total of 69 (95.8%) of 72 case customers with multiple restaurant exposures reported eating in 1 or more group 1 restaurants.

during the second wave blue cheese dressing was associated with illness (OR and 95% CI undefined because none of the noncase customers ate the blue cheese dressing; $P = .03$). Restaurants D and H were affected only during the second wave of the outbreak. By univariate analysis, lettuce (restaurant D: OR, 188.1; 95% CI, 37.0-1157; $P < .001$; restaurant H: OR, 31.2; 95% CI, 3.0-1417.3; $P < .001$) and many other salad bar ingredients were associated with illness at both restaurants. No independent risk for items other than lettuce was identified by multivariate analysis because most food items were eaten together as part of a lettuce salad. Restaurant G was affected only during the second wave of the outbreak. Potato

salad had the greatest association with illness (OR, 4.0; 95% CI, 1.5-11.2; $P = .005$), but could account for only half of the cases. Eating a lettuce salad was independently associated with illness (OR, 2.5; 95% CI, 1.0-6.2; $P = .04$). Eating take-out food from restaurant G, which did not usually include salad, was not associated with illness.

Although case-control studies of food exposures were not conducted at the other 6 group 1 restaurants, 4 had salad bars, with reported salad bar exposure rates for their SRE case customers ranging from 83% to 90%. The 2 restaurants without salad bars (restaurants E and J) accounted for the smallest number of case customers of all group 1 restaurants, 29 total (4%).

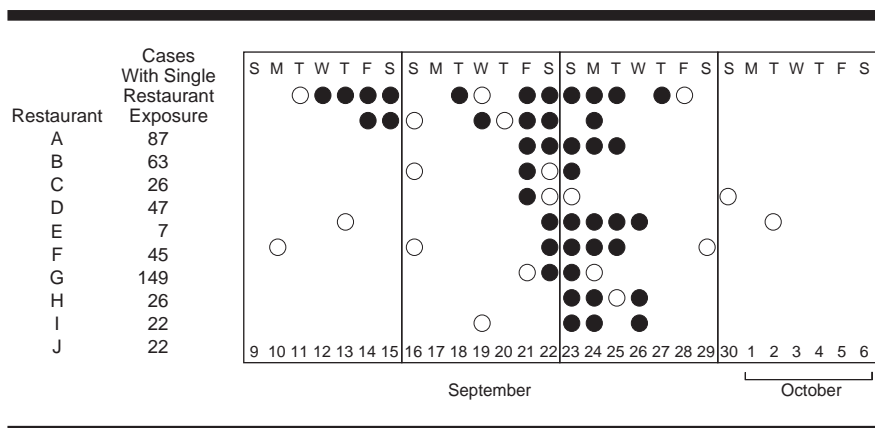


Figure 2.—Dates of exposure at group 1 restaurants reported by 494 case customers with single restaurant exposures. Circles indicate days reported by case customers; filled circles indicate days when 1 customer or more had culture-confirmed *Salmonella Typhimurium* infection.

Two of the group 1 restaurants (restaurants A and B) had banquet facilities. No cases were identified among attendees of 20 banquets during the outbreak period, after customers with other restaurant exposures were excluded. Banquet salad bar items were made up in the same kitchen as the public salad bar items, but the banquet salad bars had a more restricted choice of foods and were in operation for only 1 to 1½ hours per day. The sources of foods placed on the public salad bars were the same as those for banquets.

Investigation of Illness Among Restaurant Employees

During September 1984, 254 employees worked at group 1 restaurants; 242 (95%) were interviewed. Of these, 56 (23%) met the clinical case definition, 41 (17%) had at least 1 symptom but did not meet the case definition, and 145 (60%) were asymptomatic. At least 1 stool specimen was submitted by 231 employees (91%). Specimens from 74 (32%) were culture-positive, including those from 39 employees whose symptoms met the case definition, 16 employees with at least 1 symptom but who would not have met the case definition except for their positive culture, and 19 asymptomatic employees. Of the 19 asymptomatic culture-positive employees, only 3 had possible exposures to another group 1 restaurant or to ill friends or family members.

Onset of symptoms in employees did not, in general, precede exposure among restaurant customers. Five case employees (2 culture-confirmed) at 4 group 1 restaurants (restaurants C, D, F, and G) reported onset of illness before September 19, during the first wave of the outbreak. They had not worked at either restaurant (restaurants A and B) involved in that early wave, nor had they eaten at those restaurants on a date when any case

customer was exposed in the early wave. There was no known social contact between the 5 case employees and any employee of restaurants A or B.

Detailed information on work schedules was available for employees of 8 of the 10 group 1 restaurants (all but restaurants I and F), including data on 66 symptomatic case employees. Assuming an average symptom duration of 3 days, then 40 case employees (61%) worked while symptomatic. When the work schedules of 3 case employees with early-onset illness were compared with dates reported for case customer exposure to their restaurant, 1 case employee's work schedule closely coincided with customer exposure. This employee had onset of symptoms on September 10, worked at restaurant G, and had primary responsibility for preparing the salads that were consumed by customers, including the potato salad that was most strongly associated with illness at this restaurant. This employee ate regularly from the salad bar at work, but had not eaten at either of the 2 restaurants with early involvement in the outbreak and reported having no social contacts with other ill employees of any other restaurant.

A total of 307 persons completed the second employee survey, including 227 (89%) of 254 employees of group 1 restaurants. The attack rate (54%) for those employees who ate at their own salad bars was significantly greater than the attack rate (30%) for those who did not (RR, 1.8; 95% CI, 1.2-2.7; $P < .01$). This was true for case employees who were ill in the first wave and for those who were ill in the second wave, compared separately with control employees. Excluding employees who became ill in the first wave, the attack rate (53%) for those employees who ate at another group 1 restaurant salad bar also was greater than the attack rate

(28%) for those who did not (RR, 1.9; 95% CI, 1.2-2.9; $P = .01$). There was no association between illness and female sex (after controlling for eating from the salad bar), type or frequency of work performed, number of restaurant meals per week, amount of water consumed at work, raw egg consumption, raw milk consumption, antacid use, or travel.

Laboratory Investigations

Salmonella Typhimurium was isolated from stool specimens of 388 patients (52%). The outbreak strain did not ferment dulcitol, which is an unusual biochemical characteristic found in only about 2% of nontyphoidal salmonellae.¹¹ The outbreak strain was sensitive to ampicillin, cephalothin sodium, chloramphenicol, gentamicin sulfate, kanamycin sulfate, nalidixic acid, sulfisoxazole, and trimethoprim-sulfamethoxazole. Intermediate sensitivity was noted to tetracycline and streptomycin sulfate. Plasmid profiles were determined^{6,7} for 52 outbreak-associated isolates, including an isolate from at least 1 case employee and 1 case customer from each group 1 restaurant. All outbreak isolates had the same plasmid profile, with a single plasmid of approximately 60 Md.

Salmonella Typhimurium was isolated from blue cheese salad dressing collected from restaurant B during the second wave of the outbreak, but was not isolated from dry mix used to prepare the dressing. *Salmonella Typhimurium* was not isolated from cultures of lettuce from restaurants D and G, which came from the same lettuce shipments used during the outbreak.

None of 6 *S Typhimurium* isolates collected in Oregon from sporadically occurring cases between July and December 1984 resembled the outbreak strain from The Dalles. Two isolates of *S Typhimurium* from 2 other outbreaks that occurred in Oregon during that time did resemble the outbreak strain by dulcitol metabolism, antibiogram, plasmid profile, and restriction endonuclease digests of plasmid DNA.

The 2 outbreaks included an outbreak in August 1984 affecting 26 persons who became ill after eating at a hospital cafeteria in the central Willamette Valley of Oregon. Illness was associated with eating ranch dressing at the salad bar. The other outbreak of *S Typhimurium* occurred after a banquet at a hotel in Portland, Ore, in December 1984, affecting at least 36 persons; illness was associated with eating rare roast beef. Previously, in November 1984, another outbreak of *S Typhimurium* occurred after a banquet at the same Portland hotel and affected at least 73 persons; illness was also associated with eating rare roast

beef. That outbreak strain had a single plasmid similar to The Dalles strain, but no further laboratory comparisons were made. No links were identified between these outbreaks and the outbreak in The Dalles.

The 1979 to 1980 national survey included 233 strains of *S* Typhimurium (excluding variant copenhagen); none had antibiograms similar to The Dalles outbreak strain.⁸ The 1984 through 1985 national survey included 175 strains of *S* Typhimurium (excluding variant copenhagen); 35 strains had antibiograms similar to the strain from The Dalles, and 6 of these did not ferment dulcitol.⁹ One of the 6 strains was epidemiologically linked to The Dalles outbreak, but the other 5 isolates had no known link with the The Dalles outbreak.

Among 34 animal *S* Typhimurium isolates from the National Veterinary Services Laboratory collected from June 1984 through November 1984, 1 isolate that did not ferment dulcitol, collected from a turkey in June 1984, matched the outbreak strain by plasmid restriction endonuclease analysis.

Environmental Studies

Review of records at the municipal water department showed no evidence of water treatment failure in September 1984. Tap water samples from 10 restaurants were negative for bacteria and had acceptable turbidity readings, and 9 had chlorine residuals of at least 1.0 mg/L.

Detailed information on distributors and suppliers was collected for 8 of the group 1 restaurants. Of 40 food items served at 4 or more of the 8 restaurants, no supplier or distributor provided a single food for more than 4 restaurants. There was no common supplier or distributor for any of the foods served by the 2 restaurants involved in the first wave of illness. Many of the distributors served large areas in Oregon and Washington.

Sanitary inspections revealed minor violations of hygienic food-handling practices in some restaurants. Employees commonly put out fresh, full containers of a food item on the salad bar, but then placed the remainder from the old container on top of the fresh items. All salad bars were ice chilled. An evaluation of temperatures maintained on a typical ice-chilled salad bar showed that the surface of a bowl of potato salad was likely to reach 13°C to 16°C (55°F-60°F), which exceeds the maximal temperature of 7°C (45°F) recommended by the Food and Drug Administration. In 1 restaurant, there was no soap dispenser or towel in the employee rest room.

Criminal Investigation

During the criminal investigation, testimony by commune members indicated that the outbreak in The Dalles was the result of deliberate *S* Typhimurium contamination of salad bars in multiple restaurants by residents of Rajneeshpuram.¹³ Clandestine laboratories in Rajneeshpuram were used to prepare cultures of *S* Typhimurium that were poured on food items on salad bars and, in some restaurants, into coffee creamers. Commune members said they were testing a plan to incapacitate voters in preparation for an upcoming election. They intended to make citizens of The Dalles sick on election day to prevent them from voting and thus influence the outcome of the election. The information obtained from informant testimony was incomplete or insufficiently precise to allow direct comparison of dates of contamination with dates of exposure for case customers and case employees on a restaurant-by-restaurant basis. It is likely that some salad bars were contaminated more than once. Informant testimony did indicate that other restaurants, in addition to the 10 identified as group 1 restaurants, might have been targets and that other foods were deliberately contaminated. In addition, produce in at least 1 supermarket was contaminated with *S* Typhimurium and plans were made to contaminate city water.¹³

Oregon State and FBI investigators confiscated an open vial containing a standard strain of *S* Typhimurium (American Type Culture Collection 14028, Rockville, Md) from the clinic laboratory in Rajneeshpuram. Clinic records indicated that the laboratory had obtained this vial from a commercial supplier of biologic products before the outbreak. The *S* Typhimurium strain was indistinguishable from the outbreak strain by antibiogram, biochemical markers, plasmid profiles, and restriction endonuclease digestion of plasmid DNA.

On March 19, 1986, 2 commune members were indicted for conspiring to tamper with consumer products by poisoning food in violation of the federal antitampering act.^{12,13} In April 1986, the defendants pleaded guilty to the charges, and in July 1986 they were sentenced to 4½ years in prison, to serve concurrently with other sentences.¹⁴

COMMENT

This outbreak of salmonellosis, affecting at least 751 persons, was caused by intentional contamination of restaurant salad bars by members of a religious commune. It was the largest outbreak of foodborne disease reported to CDC in the United States in 1984. Despite extensive investigation, the source of *S* Typhimurium

initially went unrecognized. It was not until more than a year after the outbreak that sufficient evidence had accumulated to link the religious commune with the outbreak. Essential evidence was collected during the course of criminal investigations independent from the epidemiologic field investigation.

There was no evidence to suggest that the *S* Typhimurium was waterborne. Employee illness was not associated with water consumption, and affected restaurants were served by 2 different water systems. Unaffected restaurants shared the same water supply with affected restaurants. Water testing detected no evidence of contamination during the epidemic period.

The outbreak was clearly associated with food consumption at restaurants. Almost all case patients either worked at a restaurant in The Dalles or reported eating at 1 or more restaurants located in the town during the week before onset of illness. Many culture-confirmed cases occurred in nonresidents who had a single restaurant meal as their sole exposure. Self-service salad bars were implicated in transmission of *S* Typhimurium. Affected restaurants in The Dalles were much more likely to have a self-service salad bar than were unaffected restaurants, and eating food from self-service salad bars was highly associated with disease. Culture of salad dressing in 1 restaurant yielded the outbreak strain. The incidence of cases declined abruptly after all salad bars were closed, and this intervention may have terminated the outbreak. However, these findings were difficult to reconcile with the observations that sanitary practices in implicated restaurants were not grossly deficient, private banquets with salad bars were not affected, and no food sources were common to the majority of affected restaurants. Therefore, other possible modes of transmission were considered.

Transmission of nontyphoidal salmonellae from infected food handlers has been documented uncommonly in epidemiologic investigations.¹⁵⁻¹⁹ In The Dalles outbreak, infected food handlers may have contributed to the spread of infection by inadvertent contamination of foods at restaurants where they worked. Some ill employees continued to work until they were excluded by the health department. Direct contamination of foods by ill employees may have occurred at 1 restaurant without a salad bar because of the lack of soap and hand towels in the employee lavatory. In 1 affected restaurant with a salad bar, a case employee was identified who prepared the salad bar food items, including the implicated potato salad, and whose work schedule coin-

cided with the dates of exposure reported by case customers. Nonetheless, other findings suggested that contamination by employees was not the most important factor in transmission. Eating at restaurant salad bars was a risk factor for employees, not just customers. Exclusion of symptomatic and asymptomatic case employees occurred several days after the abrupt decline in new cases had begun, suggesting that exclusion of infected employees did not play a large role in terminating the outbreak.

Laboratory analyses were conducted that compared the outbreak strain with available human and animal isolates from national surveys. The characteristic antibiotic-sensitivity pattern, biochemical testing results, and plasmid analysis conclusively demonstrated a single outbreak strain and excluded the remote possibility of independent, simultaneous outbreaks. The outbreak strain was not common before the outbreak. None of the human isolates from the 2 national surveys, excluding several isolates obtained after the outbreak, matched The Dalles strain. The 1 animal isolate that matched the outbreak strain had no identifiable epidemiologic link to The Dalles outbreak. Isolates from 3 other 1984 Oregon outbreaks matched the outbreak strain, including a salad bar-associated outbreak which preceded The Dalles outbreak. However, no connection between these outbreaks and The Dalles outbreak was ever established.

The source of the outbreak strain of *S* Typhimurium was finally identified in October 1985. During a search by law enforcement agents, an Oregon Public Health Laboratory official found an open vial of commercial stock culture disks containing *S* Typhimurium in a clinical laboratory operated by the religious commune. Records showed that it was purchased before the outbreak,¹³ and laboratory testing during the following months demonstrated that the isolate matched the outbreak strain. Informant testimony provided additional information about the motives for the conspiracy and details of its implementation.^{5,12-14} Testimony indicated that several attacks were directed at some restaurants. In some restaurants, liquid coffee creamer was also contaminated, produce was contaminated in a grocery store, and plans were made to contaminate municipal water supplies.^{5,12-14} The epidemiologic investigation did not identify these other exposures as risk factors. The source of infection for employees who became ill before customer exposure was documented remains unknown. These illnesses may have been the result of an abortive early attempt at contamination. The informants indicated that the

saboteurs were frustrated when their initial attempts did not cause widespread illness and they may have used higher inoculums in later attacks.¹³

In retrospect, intentional contamination is consistent with the epidemiologic findings. When *S* Typhimurium was introduced into food on the ice-chilled salad bars, the holding temperatures may have permitted propagation; reuse of foods and addition of old products on top of new ones allowed *S* Typhimurium to persist for several days, and other foods on the salad bar may have been cross-contaminated. Intentional contamination explains why different foods were contaminated in different restaurants and the nearly simultaneous involvement of many restaurants despite the lack of common food sources. It also explains why persons attending private banquets at 2 affected restaurants did not become ill even though salad bars were set up for these events. Most importantly, intentional contamination explains the observations without relying on multiple complex modes of transmission.

The possibility that intentional contamination caused the outbreak was specifically considered early in the investigation, but this hypothesis was initially rejected for several reasons. (1) No motive was apparent. Despite concern in The Dalles about the potential for election fraud, the outbreak of illness in September and October was not obviously related with elections occurring in November. We had not considered that this incident had merely been a trial run for further attacks at the time of the election. (2) No one claimed responsibility for the incident, and no demands or ultimatums were issued. We assumed that if the motive was either extortion or terrorism, a public statement would have been issued to intimidate or create widespread fear. In fact, the incident was planned as a covert tactical strike. (3) Law enforcement officers investigated the few questionable activities reported among restaurant patrons and did not establish a recognizable pattern of unusual behavior. (4) No disgruntled employee was identified who might seek revenge on their employer. The criminal investigation confirmed that restaurant employees did not participate in the contamination efforts. (5) The epidemic exposure curves indicated that salad bars were contaminated multiple times during a several-week period, suggesting that a sustained source of *S* Typhimurium was necessary. It seemed more likely to us that a saboteur would have acted on 1 occasion, rather than risk repeated attacks and exposure. (6) A few employees had onset of illness before the recognized patron exposures in their restaurants. (7) To our knowl-

edge, such an event had never happened. We were aware of only 2 reports of foodborne illness caused by intentional contamination with biologic agents, and neither incident appeared to be politically motivated.¹² (8) On the basis of our experience in other investigations, we believed that other hypotheses, although more complicated, appeared more likely, because individually each of the components had been well documented in other outbreaks. (9) Finally, even in thoroughly investigated outbreaks, the source sometimes remains occult, and, of all the reasons considered for failing to identify a source, this would be the most common.

There was a risk that publicity about this outbreak may have had the unfortunate side effect of inciting other events, similar to the copycat poisonings following the Tylenol-cyanide poisonings in 1982. When the cause of the outbreak was identified, it was reported by the regional news media; however, we know of no additional outbreaks motivated by these reports. A report of the findings of the CDC investigation was distributed to state and territorial public health officials, but not submitted for publication. The recent discovery of the stockpiling and use of biological agents by the Japanese cult Aum Shinrikyo serves to remind us of a continuing threat that biological weapons might be used by other terrorist groups in the future.²⁰ It is hoped that wider dissemination today of the epidemiologic findings from The Dalles outbreak will lead to greater awareness of the possibility of other incidents and earlier recognition, when or if a similar incident occurs. This potential benefit should outweigh the risk of a copycat incident. It may be that with a higher index of suspicion in The Dalles, the source of *S* Typhimurium would have been identified sooner. However, the epidemiologic method is inherently limited; it determines risk and association and can indicate how contamination probably occurred. It cannot establish motive.

Can another outbreak like the one that occurred in The Dalles be prevented? It seems unlikely that any regulation of commercially available pathogens could have prevented this outbreak. It would not be necessary to purchase them because this type of culture could be easily obtained from clinical isolates or from raw foods of animal origin available in grocery stores. Production of large quantities of bacteria is inexpensive and involves simple equipment and skills. Standard practices for maintaining salad bars may be inadequate to prevent similar outbreaks in the future with salmonellae or other pathogens. As in many areas of our open society, current practices are inad-

equate to prevent deliberate contamination of food items by customers.

With this in mind, the public is best protected when health care professionals and laboratories cooperate with local and state health departments to report notifiable diseases and unusual disease clusters. Routine reporting is essential in disease surveillance at both the local and national level, and efforts to improve surveillance will assist in the detection of future outbreaks in general. The epidemiologic approach to an outbreak need not be changed. The methods of determining the pathogen, vehicle, and route of contamination and

relating them to time, place, and person remain the same. On the basis of our experiences in The Dalles, we also suggest that if investigation of a large and cryptic outbreak implicates a mechanism of contamination that does not resemble established patterns, then the possibility of intentional contamination should be considered and law enforcement agencies should be asked to consider undertaking an independent investigation.

This article is dedicated to the memory of Laurence R. Foster, MD, MPH, in honor of his investigation of this outbreak and his inspirational leadership as Oregon State Epidemiologist.

References

1. Joseph PR, Millar JD, Henderson DA. An outbreak of hepatitis due to food contamination. *N Engl J Med*. 1965;273:188-194.
2. Phills JA, Harrold AJ, Whiteman GV, Perelmuter L. Pulmonary infiltrates, asthma, and eosinophilia due to *Ascaris suum* infestation in man. *N Engl J Med*. 1972;286:965-970.
3. Callister S, Long J, Zaitz LL. For love and money: the Rajneeshees from India to Oregon. *The Oregonian*. June 30-July 19, 1985;suppl:36.
4. Callister S, Long J, Zaitz LL. On the road again. *The Oregonian*. December 30, 1985: B1-B10.
5. FitzGerald F. *Cities on a Hill: A Journey Through Contemporary American Cultures*. New York, NY: Simon & Schuster; 1986.
6. Birnboim HC, Doly J. A rapid alkaline extraction procedure for screening recombinant plasmid DNA. *Nucleic Acids Res*. 1979;7:1513-1523.
7. Maniatis T, Fritsch EF, Sambrook J. *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory; 1982: 150-162.
8. Riley LW, Cohen ML, Seals JE, et al. Importance of host factors in human salmonellosis caused by multiresistant strains of *Salmonella*. *J Infect Dis*. 1984;149:878-883.
9. MacDonald KL, Cohen ML, Hargrett-Bean NT, et al. Changes in antimicrobial resistance of *Salmonella* isolated from humans in the United States. *JAMA*. 1987;258:1496-1499.
10. Dean AG, Dean JA, Coulombier D, et al. *Epi Info, Version 6: A Word Processing, Database, and Statistics Program for Public Health on IBM-Compatible Microcomputers*. Atlanta, Ga: Centers for Disease Control and Prevention; 1995.
11. Martin WJ, Washington JA II. Enterobacteriaceae. In: Lennette EH, Balows A, Hausler WJ Jr, Truant JP, eds. *Manual of Clinical Microbiology*. 3rd ed. Washington, DC: American Society for Microbiology; 1980: 207.
12. Laatz J. Sheela indicted in The Dalles poisoning plot. *The Oregonian*. March 20, 1986:A1, E6.
13. *US v Sheela et al*, CR 86-53, Indictment (D Ore 1986), based on 18 USC § 1365(a) and 1365(e).
14. Laatz J. Sheela sentenced to prison: \$400,000 fine added to term behind bars. *The Oregonian*. July 23, 1986:A1, B2.
15. Pether JVS, Scott RJD. *Salmonella* carriers: are they dangerous? a study to identify finger contamination with *Salmonellae* by convalescent carriers. *J Infect*. 1982;5:81-88.
16. Roberts D. Factors contributing to outbreaks of food poisoning in England and Wales, 1970-1979. *J Hygiene*. 1982;89:491-498.
17. Buchwald DS, Blaser MJ. A review of human salmonellosis, II: duration of excretion following infection with nontyphoidal *Salmonella*. *Rev Infect Dis*. 1984;6:345-356.
18. Rubenstein AD, MacCreedy RA. Epidemic *Salmonella newport* infection in a metropolitan area. *N Engl J Med*. 1953;248:527-530.
19. Blaser MJ, Rafuse EM, Wells JG, Pollard RA, Feldman RA. An outbreak of salmonellosis involving multiple vehicles. *Am J Epidemiol*. 1981;114: 663-670.
20. Kaplan DE, Marshall A. *The Cult at the End of the World*. New York, NY: Crown Publishing Group; 1996.