A Large Outbreak of Foodborne Salmonellosis On the Navajo Nation Indian Reservation, Epidemiology and Secondary Transmission

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Abstract: In September 1974, the largest outbreak of foodborne salmonellosis ever reported to the Center for Disease Control—affecting an estimated 3,400 persons—occurred on the Navajo Nation Indian Reservation. The responsible agent was *Salmonella newport* and the vehicle of transmission was potato salad served to an estimated 11,000 persons at a free barbecue. The cooked ingredients of the potato salad had been stored for up to 16 hours at improper holding temperatures.

The magnitude of the outbreak allowed us to study secondary transmission by calculating the rates of diarrheal illness during the 2 weeks following the outbreak in persons who did not attend the barbecue and by examining the results of stool cultures obtained after the outbreak. We found no secondary transmission.

We conclude that a health official should monitor food preparation and service at large social gatherings and that person-to-person transmission of salmonellosis probably does not normally occur even in settings considered highly conducive to cross-infection. (Am. J. Public Health 67:1071–1076, 1977)

Introduction

Fairs are a major form of outdoor recreation on the Navajo Nation Indian Reservation and the Indians travel considerable distances to attend them. The Annual Navajo Nation Fair, billed as the "World's Largest American Indian Fair," is held each fall in Window Rock, Arizona. The 1974 fair, held September 5–8, was attended by an estimated 80,000 people; a free barbecue was featured on the opening day. This paper describes the epidemiology of the large outbreak of salmonellosis that ensued including the food-handling errors that caused it and recommends measures to prevent similar large-scale episodes. The paper also presents epidemiologic and laboratory data indicating that secondary transmission of salmonellosis did not occur in the outbreak.

The Outbreak

Beginning on the evening of September 6, and during the next few days, several hundred people with gastrointestinal illness sought medical attention at the one hospital near Window Rock and at a hospital in Gallup, New Mexico. Over 130 of them had stool cultures positive for a Salmonella Group C₂ organism later identified as *Salmonella newport*, a

bacterium rarely isolated by the laboratory of the hospital near Window Rock either before or after the outbreak (Figure 1). On September 13, 1974, the Center for Disease Control (CDC) was asked to assist in an epidemiologic investigation of the outbreak.

Investigation

Preliminary studies suggested 2 likely vehicles of transmission: the Window Rock community water supply or food served at the fair's barbecue. Evidence favoring a water source included our finding a broken water pipe on the fair grounds in an area soiled with animal excrement and our identification of persons living or working in Window Rock who did not attend the barbecue and had a diarrheal illness following the fair that was consistent with salmonella enterocolitis. The barbecue was suspect because food preparation practices were reportedly improper and because those who had attended the barbecue appeared to have a high attack rate of illness.

Survey

To determine the extent of the outbreak, the vehicle of transmission, and the rate of secondary transmission, we conducted a large questionnaire survey between September 19 and 25. Since one survey objective was to determine whether the Window Rock water system was responsible, we centered the survey on a 110-square-mile rectangular area served partly by the Window Rock community water system and partly by the independent Ft. Defiance community water system, which served as a control. The total area
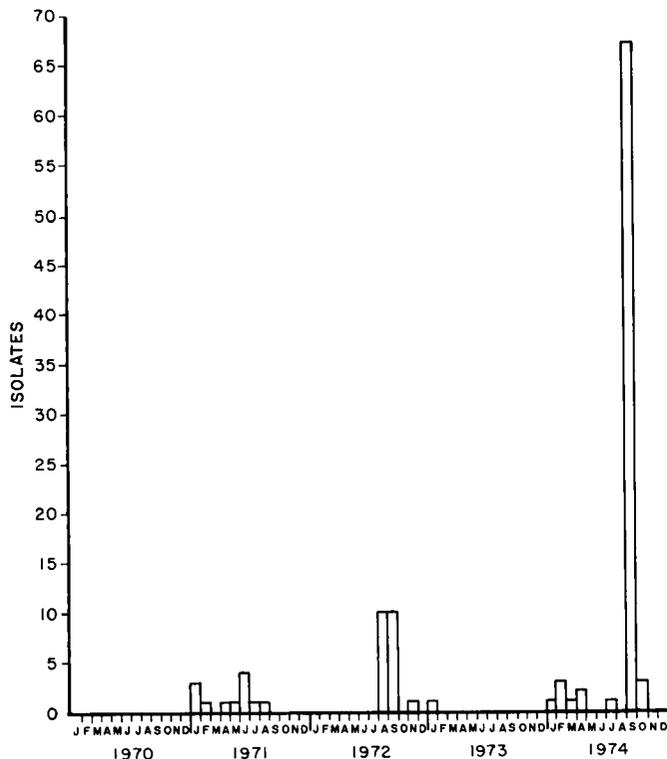
Figure 1—Salmonella Group C_2 Stool Isolates at Hospital, January 1970–December 1974

contained an estimated 7,500 people living in roughly 1,800 dwellings (which included hogans, trailers, houses, and apartments). Using recently made maps of dwellings within the area, we randomly selected 500 dwellings, housing an estimated 2,000 persons, for a visit by an interviewer who was to complete a questionnaire on each person living in the dwelling.

Public Health Service personnel and community health representatives administered the questionnaire in person. They inquired about the occurrence and characteristics of diarrheal illness, the type and location of the household water supply, and the average amount of water consumed daily. They obtained information about attendance at the fair, about the amount of water consumed at the fair, and about food consumption and time of eating at the barbecue. In addition, they obtained information on secondary transmission.

Data in this report were evaluated by the 2-tailed Student's t test; all probabilities less than .0001 are expressed as p < .0001.

Of the 500 projected dwellings, 450 (90 per cent) were visited at least once; 73 of these dwellings were temporarily or permanently vacant and persons living in one dwelling refused interview. In the 376 remaining dwellings, an interpretable response to the question on recent illness was obtained from 1,637 (98 per cent) of the 1,673 occupants. Between September 5 and 18, 204 (12.5 per cent) persons in 117 (31 per cent) dwellings had onset of diarrhea (defined as abnormally loose and frequent bowel movements). The shape

of the "epidemic curve" showing when these illnesses began was consistent with a point common source outbreak (Figure 2). All illnesses that occurred on September 5 began after 12:00 noon, and over half had onset after 9:30 p.m. Beginning September 7, illness in persons who did not attend the barbecue constituted an increasing proportion of the new illnesses.

To determine the vehicle of transmission, a case of salmonella enterocolitis was defined as diarrhea with onset 5–72 hours (the approximate range of incubation periods for the disease) after initial exposure to a potential vehicle on September 5. Varying the time of initial exposure to each vehicle of transmission allowed a more accurate separation of ill and well persons in testing each potential vehicle for a significant association with illness. If, instead, a fixed 5- 72-hour period following exposure to any one particular potential vehicle had been selected for testing the association with illness of all potential vehicles, a bias in favor of incriminating that particular potential vehicle would have been introduced.

Attendance at the fair (Table 1) was highly associated with illness (p < .0001). Since 54 per cent of dwellings surveyed had at least one member who attended the fair, the association of water supply and illness independent of fair attendance was tested. Of 869 persons who did not attend the fair and whose household water was derived from either of the 2 community water supplies, only 5 became ill—2 in Ft. Defiance and 3 in Window Rock; persons living in these 2 areas did not have significantly different rates of illness.
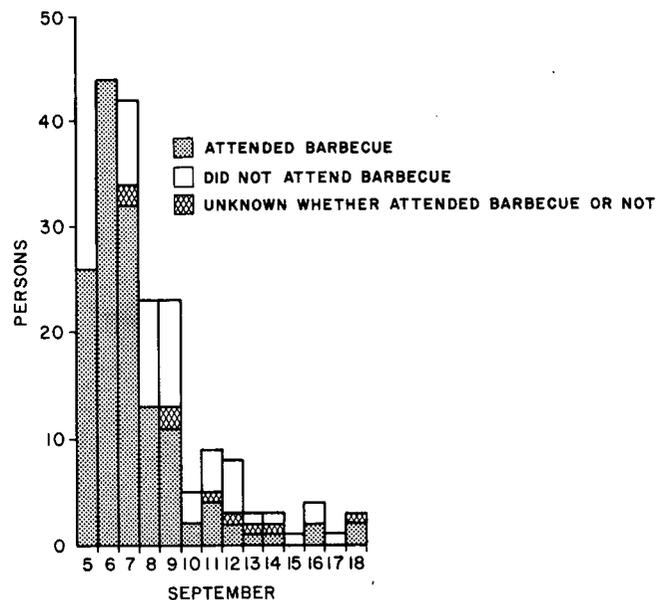

Figure 2—Surveyed Persons with Diarrheal Illness, By Date of Onset, September 5–18, 1974 (Number of Persons Surveyed = 1,637).

TABLE 1—Attack Rate by Attendance at Fair

Status	Persons Ill	Persons Not Ill	Total	%
Attended Fair	111	400	511	21.7*
Did Not Attend Fair	7	1,108	1,115	0.6*

*p < .0001

Attendance at the barbecue (Table 2) was highly associated with illness (p < .0001). Although the municipal water supply was eliminated as a vehicle of transmission, the pipeline supplying the fairgrounds could have been contaminated. However, there was no significant difference in illness rates between those who drank and did not drink water at the fair, whether or not they attended the barbecue.

Since barbecue attendance was strongly associated with illness, the time of initial exposure in the case definition of salmonella enterocolitis could be fixed in time. Thus, for further analysis, a case was defined as diarrhea 5–72 hours after eating at the barbecue. Since the attack rate in surveyed persons who attended the barbecue was 30.9 per cent and the estimated attendance at the barbecue was 11,000 persons, a projected 3,400 cases of salmonellosis occurred.

Five foods and one beverage (coffee) were served at the barbecue and water was available at fountains; of these, both beans and potato salad were significantly associated with illness (Table 3). The associations of these two foods were studied further by the technique of cross-table analysis. For persons who ate beans, eating potato salad was significantly associated with illness (p < .05); for persons who did not eat beans, eating potato salad was not significantly associated with illness, but the number of persons who did not eat beans was small (Table 4). For persons who ate or did not eat potato salad, eating beans was not significantly associated with illness. As noted previously, the p values are derived from the 2-tailed Student's t test.

The attack rate did not significantly differ according to race, sex, or age of persons. (Table 5). The median incubation period for cases was 29 hours; it was 30 hours for cases with severe illness, defined as diarrhea plus at least five of the following six symptoms: nausea, vomiting, fever (undocumented), chills, headache, and abdominal cramps. The median duration of illness was seven days; no relationship was found between length of incubation period and duration of illness.

Over 80 per cent of ill persons reported fever (undocumented), headache, chills, abdominal cramps, and nausea,

TABLE 2—Attack Rate in Fair Attenders by Attendance at Barbecue

Status	Persons Ill	Persons Not Ill	Total	%
Attended Barbecue	105	235	340	30.9*
Did Not Attend Barbecue	6	163	169	3.6*

*p < .0001

and 65 per cent reported vomiting (Table 6). Forty per cent visited a hospital, clinic, or medicine man.

Food Preparation

Volunteers who had helped prepare the barbecue food were given questionnaires inquiring into roles played in food preparation and service and into the occurrence of diarrheal illness; they refused to submit a stool specimen or to allow a rectal swab to be taken for culture. The sites of food preparation and service were visited. Records of temperatures for the day of the barbecue were obtained from the Gallup airport.

The preparation and service of food was a mammoth project. The raw ingredients for the potato salad alone amounted to 1,500 lbs. of potatoes, 400 dozen eggs, 30 lbs. of commercial dehydrated onions, 30 gallons of commercial mayonnaise, and 50 gallons of commercial relish. The food was served on paper plates to an average of 60 persons per minute and was eaten with plastic utensils.

Potato salad was prepared by steam cooking the potatoes for 2-1/2 hours and the eggs for 8–10 minutes at 250°F (121°C), on the evening of September 4; then the potatoes and eggs were crushed by hand through a new, cleaned chicken-wire mesh placed over new, cleaned garbage cans. Until mixed with the other ingredients of the potato salad the next day, the cooked eggs and potatoes were held unrefrigerated as long as 13 hours and 16 hours, respectively, during the period when temperatures at the Gallup airport ranged from 44°F (7°C) to 84°F (30°C).

Fifteen volunteers peeled the cooked eggs or grated the eggs or potatoes by hand. None of them reported a diarrheal illness during the month before the fair.

Laboratory Studies

Since no food was stored after the barbecue, samples of all foods served were obtained on September 15 from a garbage heap where leftovers had been thrown ten days before. Multiple swabs were obtained from the wire mesh used for chopping the eggs and potatoes and from the potato peeler, which had not been used since the barbecue. All these specimens were examined for salmonellae. Water samples were obtained from multiple sites at the fair grounds and various points in the community water supply and examined for coliform bacteria and salmonellae.

All food, water, and environmental samples were negative for salmonellae. Coliform counts on all water samples examined were less than 1 per 100 ml of water.

Study of Secondary Transmission

To determine if secondary transmission occurred, the rates of diarrheal illness from September 6 through 18 were calculated for persons who did not attend the barbecue and who were in one of four categories of families: 1) families with an index case—the first family member who became ill 5–72 hours after eating at the barbecue; 2) families with one or more persons who attended the barbecue without subsequent illness—i.e., families with a potential asymptomatic

TABLE 3—Food- and Beverage-Specific Attack Rates in Barbecue Attenders

Food Items Served	Persons Who Ate Food				Persons Who Did Not Eat Food				p
	Ill	Not Ill	Total	Percentage Ill	Ill	Not Ill	Total	Percentage Ill	
Potato Salad	100	193	293	34.1	5	37	42	11.9	<.002
Beans	100	196	296	33.8	4	33	37	10.8	<.005
Bread	100	214	314	31.8	4	16	20	20.0	NS*
Beef	101	222	323	31.3	4	7	11	36.4	NS
Ice Cream	96	215	311	30.9	7	16	23	30.4	NS
Coffee	25	54	79	31.6	75	174	249	30.1	NS
Water	26	50	76	34.2	75	177	252	29.8	NS

*Not statistically significant

carrier; 3) families with no members who attended the barbecue but with an overnight visitor who attended the fair; and 4) families with no members who attended the barbecue and no overnight visitors who attended the fair. The rates of illness in these family categories ranged from 3.0 per cent to 6.1 per cent (Table 7) and did not differ significantly, even when the families were stratified by number of household members or by person/room ratio (a measure of crowding). Furthermore, of the 12 persons who became ill in families with an index case, four had onset less than 24 hours (specifically 2, 15, 16, and 22 hours) after the onset of illness in the index case; person-to-person transmission of salmonella enterocolitis with that rapidity would seem highly improbable.

The number of stool isolations of Group C_2 salmonella organisms at the laboratory of the hospital near Window Rock rose and fell dramatically at the time of the outbreak (Figure 1). The fall-off in isolations of Group C_2 salmonellae occurred even while the number of stool specimens sent to the hospital laboratory for culture remained at unusually high levels during the first few months following the outbreak as a result of an intensified program of culturing cases of diarrhea. The last Group C_2 organism isolated at the laboratory in 1974 was in October. This organism was not isolated there again until May 1975.

Discussion

Survey results demonstrated that barbecue attendance

was highly associated with illness. Survey and laboratory results eliminated water as a vehicle of transmission. At the barbecue, eating potato salad or eating beans was shown to be significantly associated with illness. Eating potato salad was more strongly associated, and in a comparison of attack rates for eating or not eating one of these two foods in persons who ate or did not eat the other, only eating potato salad was significantly associated with illness; this and the finding that there was a major food-handling error in the preparation of the potato salad led to the conclusion that potato salad was the vehicle of transmission of this outbreak.

The major error found in food preparation was the prolonged storage of the precooked ingredients of the potato salad at temperatures within the 44°F (7°C) to 114°F (46°C) range in which salmonellae have been shown to multiply in a variety of precooked foods.[1] The food should have been refrigerated below 42°F (5.6°C)[2]; however, it is doubtful that routine refrigeration would have adequately cooled food located in the center of such large containers.[1] *Salmonella newport* was not isolated from specimens of discarded food; however, these specimens were unsuitable for analysis by the time they were collected.

The initial source of the salmonellae in the potato salad is unknown. Any salmonellae in the raw eggs or potatoes should have been eliminated adequately in the cooking process.[2, 3] The organism was probably introduced into the eggs and/or potatoes after they were cooked, possibly by a human carrier; there was ample opportunity for transfer of the organism to the eggs and/or potatoes by any one of the 15 persons

TABLE 4—Cross-Table Analysis for Consumption of Beans and Potato Salad

Status	Ate Beans				Status	Not Eat Beans			
	Persons Ill	Persons Not Ill	Total	Percent Ill		Persons Ill	Persons Not Ill	Total	Percent Ill
Ate Potato Salad	96	174	270	36*	Ate Potato Salad	3	17	20	15**
Not Eat Potato Salad	4	21	25	16*	Not Eat Potato Salad	1	16	17	6**

*p < .05
**p > .05

TABLE 5—Race, Sex, Age—Specific Attack Rates in Barbecue Attenders

Race	Number Ill Reporting Race	Number Attending Barbecue Reporting Race	Race-Specific Attack Rates %
Navajo	90	292	30.8
White	4	15	26.7
Other	4	9	44.4

Sex	Number Ill Reporting Sex	Number Attending Barbecue Reporting Sex	Sex-Specific Attack Rates %
Male	44	144	30.6
Female	46	158	29.1

Age (Years)	Number Ill Reporting Age	Number Attending Barbecue Reporting Age	Age-Specific Attack Rates %
<10	15	62	24.2
10–19	17	68	25.0
20–29	31	75	41.3
30–39	18	53	34.0
40–49	10	37	27.0
50–59	7	27	25.9
>60	4	17	23.5

who peeled the cooked eggs or grated the eggs or potatoes by hand.

This was the largest outbreak of foodborne salmonellosis ever reported to the CDC. Because they frequently involved a large number of persons and because they are probably more likely to be reported, foodborne outbreaks associated with large banquets, picnics, and receptions contribute substantially to the total number of cases of foodborne illness reported yearly to CDC.[4] Since the logistics of adequate food storage at such events are complicated by their sheer magnitude and since non-professionals are likely to be supervising the food preparation, large gatherings should be considered high-risk settings for foodborne disease outbreaks, and a local health official, such as a county sanitarian, should monitor food preparation and service.

None of the persons surveyed who did not attend the barbecue became ill during the two days after the barbecue,

but 8–10 of them per day became ill during the next three days. This gave the appearance that secondary transmission might have occurred, but it was not demonstrated by detailed study. The dramatic decrease in isolations of Group C_2 salmonellae at the hospital near Window Rock after September 1974, was further evidence that the outbreak had not been perpetuated by secondary transmission. A possible explanation for the increased rate of diarrheal illness with onset September 7–9 in persons who did not attend the barbecue (Figure 2) and September 8–9 in persons who did attend the barbecue more than 72 hours before is that spread of other diarrheal illnesses, such as one of the acute infectious nonbacterial gastroenteritides, occurred during that period; opportunity for enhanced person-to-person transmission of such an illness among persons from the surveyed area was

TABLE 6—Symptom Complex in the 105 Surveyed Cases

Symptom	% of Patients with Symptom
Fever (undocumented)	90
Headache	87
Chills	84
Cramps	84
Nausea	81
Vomiting	65
Mucus in Diarrhea	28
Bloody Diarrhea	14

TABLE 7—Rate of Illness from September 6 through 18 in Persons Who Did Not Attend the Barbecue in Various Family Groupings

	Persons Ill	Persons Not Ill	Total	%
1. Families with Index Case	12	186	198	6.1
2. Families without Index Case	5	163	168	3.0
3. Families without Barbecue Attender but with a Visitor Attending Barbecue	9	193	202	4.5
4. Families without Barbecue Attenders or Visitor Attending Barbecue	18	580	598	3.0

provided by the increased intermingling of people at the fair, which continued with record attendance through September 8. The fact that there was a sharp drop-off in new cases of diarrheal illness in the surveyed population on September 10 (Figure 2), two days after the fair, is consistent with this hypothesis since the non-bacterial gastroenteritides appear to have incubation periods of 16–48 hours.

Our finding that secondary transmission of salmonella enterocolitis could not be demonstrated in this study is in contrast to findings of a study on another Indian reservation in which non-institutional person-to-person transmission of *Salmonella typhimurium* enterocolitis was alleged, but was not documented either by demonstrating higher rates of illness in the contacts of cases than in the contacts of controls or by demonstrating that an organism of a single phage type or antibiogram was propagated from cases to their contacts.[5] Secondary transmission was absent in the present outbreak probably because person-to-person transmission of salmonellosis does not normally occur[6], even in settings considered highly conducive to cross-infection. By way of contrast, the tremendous health problem that shigellosis presents on Indian reservations no doubt reflects the fact that person-to-person transmission is the usual mode of spread of that disease.[7] The difference in behavior between the two diseases is probably explained by the fact that, in general, a much higher dose of salmonellae than shigellae is required to cause enterocolitis. In studies in humans, 10^5 to 10^{10} viable salmonella organisms, depending upon serotype and strain, have been required to produce disease[8–10] while as few as 10 shigella organisms have done so.[11]

If illness during the second week of the surveyed period (September 12–18) in persons who did not attend the barbecue was unrelated to the barbecue, then the background level of diarrheal illness in the surveyed population that week was 1 per cent. This background level is virtually the same as that observed in a study of endemic diarrheal illness on the Apache reservation during a 13-week summer period.[12]

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