CHAPTER 2

Leptospirosis at the Bubbles

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INTRODUCTION

After completing a rotating internship and Internal Medicine residency at Cook County Hospital in Chicago, I joined the Epidemic Intelligence Service (EIS) at the Centers for Disease Control (CDC) in Atlanta in 1963. The EIS provides a 2-year experience in applied public health and field epidemiology for health professionals who have recently completed their training. Most EIS officers were physicians, who like me had just completed residency training, but the EIS program also included other health professionals, such as veterinarians, nurses, dentists, biostatisticians, and public health specialists.

I became interested in the EIS program during my year as chief resident in Internal Medicine at Cook County Hospital. When I was on the pulmonary rotation, I had cared for many patients with tuberculosis (TB), a very common disease in the 1960s at Cook County. Although some patients with TB responded well to therapy, it was very frustrating that many did not. It was common in those days for TB patients to leave the hospital against medical advice after having received a week or two of anti-TB drugs, especially if they were asked to undergo bronchoscopy, which was done then using a rigid bronchoscope. Unfortunately, the director of the chest surgery service in the hospital viewed training surgery residents to do bronchoscopy on TB patients as his most important teaching responsibility. Patients who left the hospital were often readmitted several months

later with more advanced, active TB after having stopped their treatment as soon as they became afebrile or felt better.

When I did a follow-up study of the outcome of TB treatment of about 120 patients with positive cultures 2 years earlier, the results were very discouraging. Only about a third of these patients were cured of their TB and still alive. About a third had died, often with active TB because they had discontinued their therapy and resumed drinking alcohol or injecting drugs or were just lost to follow-up by the Chicago TB clinics. This was long before directly observed treatment became the standard of care in Chicago.

The results of this study peaked my interest in public health and epidemiology. When I visited CDC before joining the EIS I became interested in public health and epidemiology because of its more comprehensive and inclusive analysis of the sociocultural and environmental determinants, as well as the biological factors, related to disease and health problems. Also, the investigation of outbreaks of disease was a fascinating and important responsibility of an epidemiologist in the EIS program, and this interested me as well.

When I joined EIS in 1963, I was assigned to the Washington State Health Department. The position included reviewing and analyzing the reports of diseases submitted by the county health departments, communicating with the public and health professionals about public health issues and prevention programs, and performing field epidemiology whenever an outbreak or cluster of illness was reported. There were many opportunities for evaluating possible outbreaks because the state epidemiologist was very competent and had established a good working relationship with most of the local health officers and practicing physicians in the state. Consequently, I investigated outbreaks of foodborne illnesses (i.e. salmonellosis, *Clostridium perfringens*, and botulism), measles, vaccine-associated polio, influenza, diphtheria, and other diseases. One of the more memorable and interesting outbreak investigations is described here.

THE BUBBLES OUTBREAK

In August 1964, I received a call from the director of the Benton-Franklin County Health Department in southeastern Washington asking for assistance in investing a cluster of cases of a febrile illness in adolescents. Several local physicians had cared for teenaged children who had become ill with a fever, headache, and muscle aches that seemed to be clinically sim-

ilar. Several of these patients had been hospitalized. Some patients had a stiff neck, but respiratory or gastrointestinal symptoms or a skin rash was uncommon.

I agreed to come and help with the investigation. I was aware that several arboviruses that cause encephalitis and meningitis, including Western equine and St. Louis Encephalitis viruses, had been frequently isolated from patients with central nervous system infections living in central and eastern Washington in the past. No horse deaths had been reported, however. All of the ill persons seemed to have recovered, and these patients seemed to be somewhat older than most reported arbovirus encephalitis cases in the past. Another possible consideration could have been a systemic fungal infection; however, central Washington was north of the area of endemicity of coccidioidomycosis (Valley Fever). Another consideration was an enterovirus infection, as these viruses are common in the summer and may cause aseptic meningitis, sometimes as outbreaks. Another, less likely possibility was amebic encephalitis. Thus, I packed my copy of Benenson's *Infectious Diseases of Man* (a public health book that has been essential to communicable disease investigators in health departments for decades, although its editor has changed over the years) and flew to eastern Washington.

When I arrived, I met with the director of the health department, and together we outlined a plan to investigate the outbreak. By that time, about 35 to 40 cases had been reported. Although we did not know which diagnosis we were dealing with, we believed an outbreak was occurring because this was a much higher number of similar illnesses in the adolescent population than any of the local practitioners or the health department routinely recognized. An initial look at the descriptive epidemiology of the cases revealed that the dates of illness onset extended back a couple of months to the middle of June. Since then, several cases had been reported each week, without obvious temporal clustering; therefore, it didn't appear to be a single exposure, common source outbreak, but perhaps an ongoing epidemic of an arbovirus or enterovirus infection should be considered. Another curious feature was that most of the cases (about 80%) were in boys. This appeared to be evidence against the outbreak being an arbovirus or an enterovirus because we were unaware of any gender predilection for illnesses caused by those viruses.

My first step after reviewing the data available at the health department was to go to the local hospital and review the charts of several typical cases

who had been hospitalized. This was long before the HIPPA legislation had been enacted, which might have complicated this approach. I took the list of names of the reported cases to the hospital and asked the record librarian to pull the charts for me. I discovered that a typical illness characteristically included fever, myalgia, headache, and shaking chills with a stiff neck reported in about half the cases (Tables 2-1 and 2-2). The illness lasted about 5 to 7 days, and respiratory symptoms, diarrhea, and rash were uncommon. Some patients had a recurrence of their symptoms a few days after they had recovered. Lumbar punctures had been done in four cases; three were normal, but one had 798 white blood cells/mm^3, of which 53% were polymorphonuclear cells and 47% were mononuclear cells. In this patient, the protein was elevated at 130 per 100 ml, and the sugar was normal (50 mg/100 ml). The normal glucose was evidence against TB or fungal meningitis. All cultures of blood, urine, and cerebrospinal fluid were sterile. There was a modest increase in the peripheral white blood cell count. Urinalysis performed on 26 patients revealed that 22 had more than five white blood cells per high-power field with a slight proteinuria (1 to 2+) in 10 cases. These clinical data were peculiar and unexpected for any common seasonal infection in a presumably healthy adolescent population.

I decided that the next step should be to interview a few typical cases as a way toward generating a hypothesis of what was going on. My colleagues at the health department said this could be arranged. Thus, I met with several recently reported cases and a couple of those who had become ill in

Table 2-1 Symptoms of 61 Children with Leptospirosis

Symptom	No.	Percentage
Fever	61	100.0
Myalgia	60	98.4
Headache	58	95.1
Shaking Chills	56	91.8
Nausea	55	90.2
Vomiting	33	54.1
Arthralgia	19	31.1
Diarrhea	7	11.5

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Table 2-2 Abnormal Physical Findings in 46 Leptospirosis Patients Seen by a Physician

Finding	Number Affected	Percentage
Fever	46	100.0
Stiff neck	23	50.0
Throat injection	14	30.4
Biphasic course	10	21.7
Adenopathy	8	17.4
Flank tenderness	5	10.9
Conjunctivitis	5	10.9
Splenomegaly	1	2.2

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June. These cases didn't report any common meals, gatherings, or special associations or common exposures with other children who had been ill; however, they usually knew several other children who had experienced similar illnesses. Finally, one of them said, "Doc, you should check out 'the Bubbles,' after which I asked what and where were the Bubbles? He offered to take me there.

The next day we went to the Bubbles. It was a concrete block structure a few miles out in the country in the field between the three surrounding towns of Kennewick, Pasco, and Richland (Figure 2-1). Connected to the small concrete structure at the Bubbles were two concrete walls about 5 feet high. These walls extended out about 7 feet. The Bubbles was a part of the irrigation system that divided the stream of irrigation water into two directions with a pump, which created bubbles when the water was pumped forcefully from below the surface. The structure was known by irrigation specialists as a "bifurcator." It was used to distribute the water in two directions and keep it flowing downstream. We were told that about 800 gallons of water passed through the bifurcator every 1 to 2 seconds. This caused the water to bubble and churn forcefully when the bifurcator was operating at full speed.

To the junior and senior high school students, however, the Bubbles was a great place to go swimming during the summer. During that summer, as was not uncommon in southeastern Washington, the temperature often exceeded 95°F to 100°F. The local swimming pool was often closed and

FIGURE 2-1 "The bubbles." The depth of the water at this point was 2.1 meters, the walls rose 1.1 meter above the water and were 3 meters apart. The churning of the water was caused by subsurface feeding.

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very crowded when it was open. Thus, the Bubbles was a great and special place to swim for teenagers. Students could stand on the concrete wall and jump into the bubbling water to be swirled around and often careen into the walls of the structure. Swimming at the Bubbles combined the joy of a swimming pool with the thrill of a ride at an amusement park. Swimming at the Bubbles often caused small skin abrasions, but it was described as "fun" and "exciting."

After learning about the Bubbles, I contacted several adolescents that I had decided were typical "cases" of the mysterious illness based on their reported symptoms of fever, headaches, myalgia, and stiff neck. Interestingly, all of the typical cases reported swimming at the Bubbles before they became ill. It then became clear to me that swimming at the Bubbles was a very important exposure that occurred before the onset of this febrile illness. The water at the Bubbles appeared clean, although it wasn't potable but used only for irrigation. The ultimate source was the Columbia River,

which was very nearby. We found later that the water at the Bubbles had a very high coliform count (>240,000 colonies per ml) and was alkaline (pH, 8.3).

We then decided to explore the irrigation canal upstream from the Bubbles for potential sources of contamination. The most effective way to do this was to hire a small plane that was used for crop dusting and fly over the irrigation canal, as there were no roads running parallel to the canal. This was an exciting trip, which resembled a roller coaster ride, as the plane was flying quite low and at slow speeds so that we could observe the canal and take pictures. This trip was quite revealing in that about 300 yards upstream from the Bubbles we noticed a herd of cattle, some of whom were also using the irrigation ditch as a watering hole to cool off (Figure 2-2). These were the only animals that we found to have direct access to the irrigation canal between the Bubbles and the origin of the canal a couple of miles upstream at the Yakima River. Thus, after the plane landed

FIGURE 2-2 Aerial view of site of epidemic of leptospirosis among swimmers in irrigation canal. Note numerous cattle upstream from irrigation canal site used for swimming.

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we decided to investigate the herd further. By then, we had decided that it was likely that the outbreak was due to leptospirosis. The exposure of cases to water that may have been contaminated by cattle and the clinical epidemiology made this diagnosis biologically plausible. This was confirmed when we obtained blood specimens from several of the typical cases and sent them to the CDC laboratory in Atlanta for testing.

There are very few laboratories in the United States or worldwide that test for leptospirosis. The assays are not commercially available, nor are they included in the standard screening panel for meningoencephalitis screening. (Because of the limited availability of laboratory confirmation of suspect cases and the protean clinical manifestations, the disease was removed from the list of officially reportable diseases by the Council of State and Territorial Epidemiologists in 1995.) The definitive serological assay is the Microscopic Agglutination Test (MAT). In this assay, various serogroups of pathogenic leptospiral organisms are incubated with dilutions of sera from persons or animals with suspected infection, and the maximal dilution of sera that will cause 50% of the organisms to agglutinate when viewed under the microscope is reported to be the MAT titer. The MAT titers are read using serial dilutions of sera and live or formalinized organisms from several different leptospiral organisms, that is, serovars, to make the diagnosis and to estimate which organism might have caused the infection. The need for live or formalin treated antigens from several leptospiral organisms explains why so few laboratories test for infection. There is a significant risk of infection among laboratory workers when the organisms are subcultured. Nevertheless, the definitive serological assay for leptospirosis and the specific organism responsible for the infection are reported as the MAT titer.

In our study, MAT antibodies against leptospires from 18 serovars were evaluated, and the titers against *Leptospira pomona* were generally highest. This was consistent with the literature, as *L. pomona* and *L. hardjo* serovars from the *L. pomona* serogroup have been reported to be the predominant organisms infecting cattle and among persons who had acquired their infection from cattle worldwide. Since we now had evidence that the leptospirosis infections were acquired by swimming at the Bubbles, we needed to take action to prevent further infections; therefore, we posted warnings and publicly advised persons against swimming in the water at the Bubbles or other areas of the irrigation canal, especially downstream from the

cattle herd. Also, the cattle were screened off to prevent them having direct access to the irrigation canal.

We also wanted to evaluate the cattle and the environment further; therefore, we collected water samples for culture from the irrigation canal and from water standing in the field where the cattle were herded. We cultured the blood samples from the children who had been ill, although all of the children had recovered from their illness before we obtained a blood specimen. *L. pomona* was recovered by guinea pig inoculation from water standing in the cattle pasture at three sites; however, cultures of water from the irrigation canal and sera from the students who had been ill were all negative (Figure 2-3).

Culturing blood and urine from the cattle was also a priority. We clearly needed assistance from a veterinarian to obtain these cultures. Fortunately, my colleague Dr. Everett (Ted) Baker, DVM, also an EIS officer, was

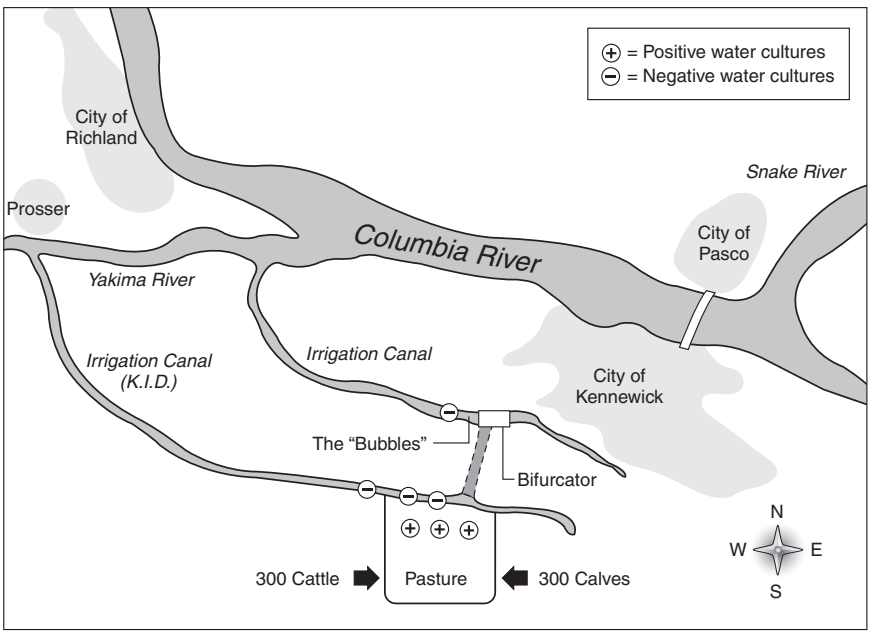

FIGURE 2-3 Schematic of the area in which outbreak of leptospirosis occurred during the summer of 1964.

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available to help obtain these specimens for culture. I was not experienced with the methods for getting a urine specimen from a cow! I knew I couldn't be successful if I just asked the animal to provide it, which is how I usually got a urine sample from my patients. I was told that often urine appeared after you massaged the cows under belly. If this failed you could poke or push the area firmly, but I don't know how Ted eventually managed to obtain the samples from the cattle.

Eventually, we found that 9 of 43 cattle (21%) were shedding *L. pomona* in their urine in September, about a month after the last human case, and 21 of 25 sera (84%) from the cattle herd were seropositive in the MAT test with the highest titers to *L. pomona*. The herd of 300 cattle had been purchased locally in the spring before the outbreak. There had been no reports of illness or unexpected deaths in the cattle and no abortions, which have commonly been reported as a consequence of animal leptospirosis. The animals had not been vaccinated for leptospirosis. We obtained blood specimens from 305 additional cattle entering two local sales yards between August 31 and October 31; 26 of these sera (8.5%) were positive for leptospiral antibodies.

In addition to warning the students and the public about the dangers of swimming or other exposures to the irrigation canal, we recognized the need for other public health measures to prevent additional cases. These included restricting the cattle from direct access to the canal and stopping the process of rill (flooding) irrigation of the pasture where the cattle were located. This could lead to contamination of the standing water with cattle urine, which could then be washed back into the irrigation canal when it rained. Leptospires can survive for considerable periods, especially in an alkaline environment. As mentioned previously, we had isolated *L. pomona* from the standing alkaline water in the pasture by guinea pig inoculation.

We made an effort to locate all of the cases in order to further define the risk exposures. Although this swimming hole was quite small, it clearly was a major site of exposure. There was also a possibility of infections occurring from exposures to the irrigation water at other areas, as the canal was several miles long winding between the fields. In order to detect additional (unreported) cases, we asked all of the known cases the names of everyone they knew who visited the Bubbles or who had swum elsewhere in the irrigation canal that summer. Another source of possible exposed persons was the signatures on the concrete wall of the Bubbles. We made certain that

we interviewed each of the persons who had left their name on the wall of the Bubbles (i.e., had "signed in" at the site).

We decided to do a larger survey after the schools reopened in September. We designed a questionnaire that included questions about having had a compatible illness during the summer, swimming anywhere in the irrigation canal during the summer, and swimming at the Bubbles during the summer. This questionnaire was distributed to the 6,062 students attending the three high schools and two junior high schools in the three neighboring towns of Kennewick, Pasco, and Richland. We found that 594 of the students (9.8%) in these five schools reported swimming at the Bubbles, and 60 had an illness confirmed serologically to be leptospirosis, for an attack rate of 10.1% among Bubbles swimmers (Table 2-3). We used a clinical definition of "suspected cases" (compatible illness), which included the reported symptoms of fever, myalgia, and headache, that were reported by over 95% of the serologically confirmed cases for our epidemiological survey. We also put notices in the local newspaper, and our interest in locating additional cases was mentioned by the local news media. We supplemented the request for reporting illnesses by reviewing local hospital and clinic records of febrile illnesses. When our case-finding efforts had been completed, we had identified 61 serologically confirmed cases (Table 2-4). All were between the ages of 12 and 19 years; 53 were

Table 2-3 Number of Students Who Swam at the Bubbles During the Summer of 1964 and Leptospirosis Attack Rates by School

	Enrollment	Swam at "Bubbles" Number (%)	Leptospirosis Cases	Swimmers' Attack Rate (%)
Kennewick High School	1,420	184 (13.0)	31	16.8
Park Jr. High School	994	54 (5.4)	6	11.1
Highland Jr. High School	746	58 (7.8)	6	10.3
Pasco High School	1,284	100 (7.8)	7	7.0
Columbia High School	1,618	198 (12.2)	10	5.1
Total	6,062	594 (9.8)	60*	10.1

* One of the 61 cases occurred in a nonstudent.
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Table 2-4 Distribution of 61 Patients with Leptospirosis by Age and Gender

Age (Years)	Male	Female	Total
12	2	0	2
13	2	1	3
14	6	0	6
15	8	1	9
16	14	3	17
17	18	2	20
18	3	0	3
19	0	1	1
Total	53	8	61

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male (86.9%) and 8 were female (13.1%). The numbers of cases increased with increasing age between 12 and 17 years (Table 2-4). In our school surveys, we found that 594 students (10.3%) reported swimming at the Bubbles during the summer; 16.0% of boys and 4.3% of girls reported swimming at the Bubbles. The proportion who reported swimming at the Bubbles also increased with age between 12 and 18 years; the distribution of those who reported swimming was similar to the age and gender distribution of the cases (Table 2-5).

The highest attack rate of leptospirosis (16.8%) was experienced by the students attending Kennewick High School. Students at Kennewick High School and Columbia High School in Richland had the highest rates of exposure to the Bubbles, 13.0% and 12.2%, respectively (Table 2-3); however, because the Bubbles was located closer to Kennewick, we believe that exposures were more frequent among students living in Kennewick than those from Richland or Pasco, but we didn't collect data on the frequency or specific dates that students swam at the Bubbles.

We did not detect any laboratory-confirmed cases of leptospirosis in those who had not swum at the Bubbles; however, a few children with leptospirosis reported swimming elsewhere in the irrigation canal in addition to the Bubbles. Nevertheless, several features of exposure to water when swimming at the Bubbles may have been important in increasing the risk of leptospirosis among these swimmers. First the churning, swirling water

Table 2-5 Students' History of Swimming at the Bubbles by Age and Gender, Summer 1964*

Age (Years)	Male			Female			Both Genders		
	Total	Swam	% Swam	Total	Swam	% Swam	Total	Swam	Swam
< 11	1	0		0	0		1	0	
11	21	2	9.5	20	1	5.0	41	3	7.3
12	224	14	6.3	278	3	1.1	502	17	3.4
13	278	24	8.6	265	15	5.7	543	39	7.2
14	320	36	11.3	302	4	1.3	622	40	6.4
15	646	84	13.0	637	22	3.5	1,283	106	8.3
16	716	122	17.0	646	38	5.9	1,362	160	11.7
17	650	161	24.8	598	33	5.5	1,248	194	15.5
18	101	30	29.7	36	4	11.1	137	34	24.8
> 18	8	0		6	0		14	0	
Unknown	3	1	33.3	2	0		5	1	20.0
Total	2,968	474	16.0	2,790	120	4.3	5,758	594	10.3

* Based on questionnaires answered by 5,758 students.
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at the Bubbles often resulted in abrasions when the swimmers were thrown against the concrete walls of the structure, providing a source of entry for *L. pomona* organisms. Second, diving into the water usually resulted in immersion of the swimmers head, exposing the conjunctiva as a site of entry of the organisms. Cases often reported recurring exposure; only three of the confirmed cases reported swimming at the Bubbles only once during the summer. Their illnesses had onset 7 to 10 days after their exposure. In addition, the number of cases increased about 10 days after the warmest day in June, when the ambient temperature reached 97°F and a similar period after the temperatures exceeded 100°F between July 10 and July 14 (Figure 2-4). We also learned that the water flow was slowed on July 13 and July 14 to facilitate repairs to the Bubbles. We suspect that the number of students exposed to the Bubbles was high during these very warm days and that the risk of infection among swimmers may have increased when the rate of water flow decreased, but we could not confirm this level of detail in our interviews.

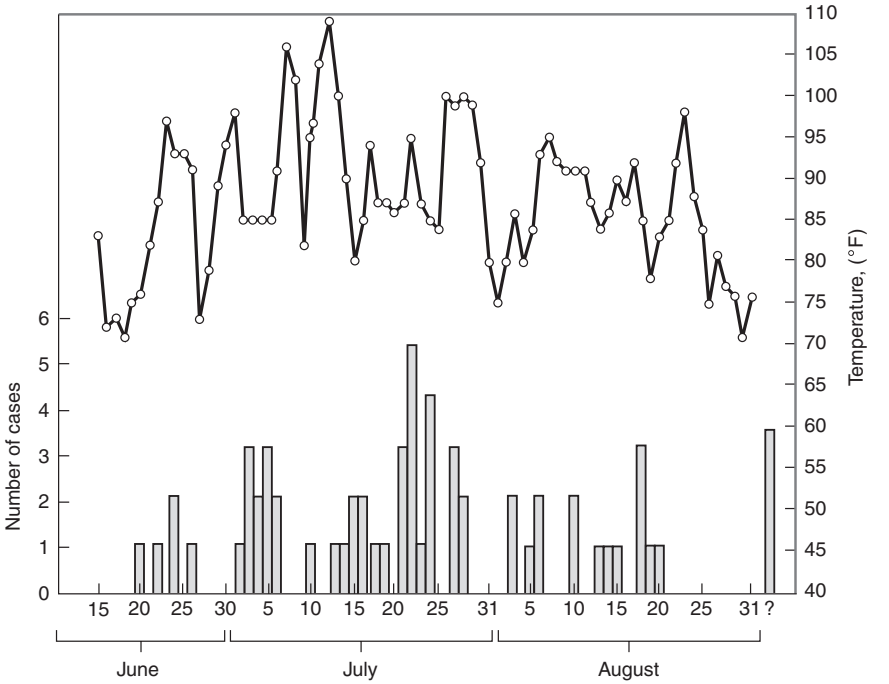

FIGURE 2-4 Cases of leptospirosis by date of onset of symptoms and daily maximum temperature, June 15–August 31, 1964.

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LABORATORY STUDIES OF THE OUTBREAK

We were very fortunate to have access to the excellent Leptospirosis Reference Laboratory at the CDC in the investigation of this outbreak. Many suspected outbreaks of leptospirosis have not had laboratory confirmation of the cases or the animal reservoir as detection of the organisms or the serological response to leptospiral infection is highly specialized and available in only a few reference laboratories.

Recovery of leptospiral organisms in culture requires special media and often very long incubation times. Primary cultures are retained for up to 13 weeks before being discarded, if there is no growth. When there is growth, it usually occurs within 10 to 14 days in liquid media.[1] Growth of contaminants is inhibited by adding 5-fluorouracil to the media.

Serologic investigation of cases also requires specialized laboratories. The traditional gold-standard method of detecting a specific antibody response is the MAT, which has been described previously here. Several other genus-specific serological diagnostic assays have been described, but they are not well standardized or widely available.

In this outbreak the Leptospirosis Reference Laboratory at the CDC performed the MAT test on all suspect cases that resulted in the 61 laboratory-confirmed cases mentioned previously here. The CDC laboratory also tested the sera with a microscopic slide test, which is a less sensitive test than the MAT but is easier to perform in the laboratory and sometimes used as a screening assay. Among the 61 students that were positive on the MAT, only 48 were positive on the microscopic slide test. The highest titers and most frequent reactions were to *L. pomona* antigens. We did follow-up testing of 45 ill students 200 to 264 days after the outbreak. At this time, only 10 sera were MAT positive for antibodies to *L. pomona*. This decline of reactivity in the MAT test was evidence against chronic infection or re-exposure.

LEPTOSPIROSIS HISTORY, EPIDEMIOLOGY, AND CAUSATIVE ORGANISMS

The clinical features of leptospirosis in humans have been known since 1886 when Adolph Weil reported cases of febrile jaundice among sewer workers in Heidelberg, Germany.[2] Although there were other earlier reports of this syndrome,[3] the clinical disease became known as "Weil's Disease." A spirochetal organism, identified in the kidney tubules of a patient with the disease by silver staining, was reported by Stimson in 1909.[4] The spirochetes had hooked ends and Stimson called them Spirochete interrogans because of their resemblance to a question mark. The importance of rats as a carrier of the organism, which was excreted chronically in their urine, was recognized and reported by Japanese investigators in 1917.[5] After these seminal discoveries, Weil's disease came to be known as an occupational disease of sewer workers throughout the world, especially in Europe. The disease also occurred frequently among persons harvesting rice in China and other countries in Asia. The Japanese called the disease "Akiyami," or Autumnal fever. Spirochetes were detected by injecting guinea pigs with blood from infected patients by German investigators.[6] Leptospirosis in livestock was recognized several decades later.[7]

In the last couple of decades, it has been recognized that leptospirosis is a very common disease globally. The clinical picture and epidemiology of leptospirosis in humans is quite variable. The disease is quite common in the tropics and has been estimated to be one of the most common zoonotic infectious diseases of humans globally.[8] Leptospirosis has been reported not only as an occupational disease but among other populations as well. Human infections have been acquired by occupational or recreational exposures to a wide range of infected animals or their urine. A wide range of exposures have been reported to transmit the organisms. High-risk groups include miners, veterinarians, farmers, abattoir workers, sugar cane cutters, fish workers, soldiers, and other occupations having direct or indirect exposures to animals. During World War II, an outbreak of a febrile illness with a pretibial rash and splenomegaly occurred among troops at Fort Bragg, North Carolina, which became known as "Fort Bragg fever" or pretibial fever. This illness was later found to be leptospirosis caused by the *L. autumnalis* infection.[9]

In addition, several outbreaks of leptospirosis among swimmers after exposure to contaminated water have been reported. A recent comprehensive review found 26 reported water-borne outbreaks among swimmers or rafters that have occurred between 1931 and 1998.[10] Most of these outbreaks were small; however five, including this one, involved more than 60 cases. In over half of the outbreaks, the source of infection was unknown, and the serogroup of the infecting organism was estimated based on serologic evidence. The water had been contaminated by urine from cattle, pigs, dogs, or rodents in most of these outbreaks.

Human leptospirosis is acquired by direct contact with infectious material, generally water contaminated with urine from an infected animal; however, subculturing the organism in the laboratory can cause infection among laboratory personnel by direct contact or possibly by aerosol. The organism is thought to enter the body through abrasions in the skin or through the conjunctiva; however, drinking of contaminated water also has been reported to transmit infection.[10]

The protean clinical features of leptospirosis in humans include clinical Weil's disease manifested by jaundice, sepsis, and renal failure, but also aseptic meningitis, as in this outbreak, pulmonary disease, cardiac involvement, and ocular disease. In addition, animals and also humans may have abortions if the infections occur during pregnancy. Cattle can develop mastitis, and ocular disease has been seen in animals.[10]

Recently, international interest in leptospirosis has been generated by several large clusters of cases that have occurred in South and Central America after flooding from storms.[10,11] It has been recognized in the past decade that human exposures to animals have caused the emergence and re-emergence of many infectious diseases, including SARS (severe acute respiratory syndrome), hantavirus, monkeypox, HIV/AIDS, avian influenza, and many others. In fact, cross-species transmission of infectious agents may be the most significant of the many factors leading to the emergence of important infections in humans in recent times. In reality, our experience in investigating the Bubble's outbreak of leptospirosis could have been viewed as a "seminal" experience of newly emerging infections on the horizon.

LESSONS FROM THIS OUTBREAK

1. Although the most common reported infectious etiology of aseptic meningitis cases and outbreaks in the summer time are enteroviruses and arboviruses, other organisms contribute, such as leptospires, whose importance may be underappreciated because of the hurdles of laboratory diagnosis.
2. Zoonotic infections appear to have become increasingly important in the emergence of new infectious diseases in humans.
3. It is often an excellent idea to determine which exposures the infected patients believe might have caused their illness and then follow-up on their suggestion(s). Epidemiologists should "listen to their patients."
4. Recreational activities, such as swimming, hiking, and rafting, may expose persons to a wide variety of infectious risks.
5. Outbreak investigation is interesting and challenging but often requires support from several disciplines, including laboratory scientists, veterinarians, and other professionals with special skills, such as irrigation experts as in the case of this outbreak.
6. We learned several months after this outbreak had been investigated and controlled that a spill of radioactive waste into the Columbia River from the Hanford Nuclear Energy facility had occurred just before this outbreak. There was some concern among officials at the facility and the Department of Energy that the epidemic might have been related to the spill.

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