

Infectious Hepatitis, Diarrhea, and Typhoid Fever

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A NUMBER of cases of infectious hepatitis, diarrhea, and typhoid fever occurred during the period August 1954 to April 1955 within a six-block radius in Washington, D. C. Circumstances surrounding the earliest known cases indicated that the diseases might be linked to a common source, a contaminated water supply. Consequently, a three-disease epidemiological study of the approximately 7,000 persons in the area was undertaken by the District of Columbia Department of Public Health.

The incident that first attracted the attention of the investigators to this unusual chain of events took place during the week of January 3, 1955. Seven cases of diarrhea occurred among members of four households occupying a building in the 400 block of Sixth St., SW. The only person in the building who did not have the disease was a 6-month-old infant for whom all water had been boiled. The exist-

ence of yard hydrants and yard water closets in this neighborhood heightened suspicion that the water supply had been contaminated. These obsolete plumbing fixtures cross-connect the water supply with the sewer line so that fresh water standing in the riser pipes can drain into the sewer to prevent freezing in the pipes during the winter. Experience in the District of Columbia and elsewhere (1, 2) has shown that under certain conditions sewage can enter the water supply through the cross connections.

Beginning on January 13, the date the outbreak was reported to the health department, a week-long series of 26 water samples was taken from the area. Two of these samples, one from the building where the outbreak took place and one from an adjacent building, were positive for coliform organisms. Free available chlorine of 0.2 p.p.m. or more was present in all the 26 samples except 3 which came from the buildings producing the coliform-positive samples. The chlorine demand thus demonstrated in this restricted area was further evidence of local contamination of the water supply.

A detailed plumbing survey revealed the presence of numerous yard hydrants and yard water closets in the neighborhood. Many of them were defective. Since the four households had no social contact, were served by different dairies, and had individual kitchen facilities, the circumstantial evidence indicated that the outbreak was waterborne.

During the week of January 25, a case of infectious hepatitis occurred just four doors away from the scene of the diarrhea outbreak. This

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Dr. Ralph Paffenbarger, epidemiologist with the Public Health Service, provided technical guidance in making the study and in preparing the report.

aroused the suspicion that there might be a connection between the two incidents. Infectious hepatitis has been known to be waterborne (3-10).

The infectious hepatitis patient was a school child. Inquiry at the school revealed three other cases, and a check with 13 other schools in Southwest and Southeast Washington, four more cases. A sanitary survey of the two schools involved disclosed nothing to indicate that the disease was being spread by conditions at the schools.

The 8 infectious hepatitis patients and the 7 diarrhea patients all lived within a radius of 6 blocks in Southwest Washington. Also within this area were located three cases of typhoid fever which had occurred in the fall of 1954.

Case-Finding Survey

To determine if an epidemic of one or more of the three diseases was in progress, the health department conducted a case-finding survey March 2-16, 1955. Interest now centered about infectious hepatitis, which is not a reportable disease in the District of Columbia. As the normal incubation period of infectious hepatitis ranges from 15 to 35 days, it was decided to request information back to Thanksgiving Day, November 25, 1954, approximately one maximum incubation period before the date of onset of the earliest known case and a convenient mental landmark.

The area selected for the survey, shown in figure 1, was the smallest considered likely to yield conclusive results. Its 27 city blocks encompassed the locations of the known cases of the three diseases.

Interviews were held with members of 1,579 households out of the 1,955 households in the area, yielding information on 5,519, or 81 percent, of the estimated 6,800 persons living in the area.

Ratios of yard hydrants and yard water closets to the population were determined for possible correlation with attack rates of the three diseases. Information on yellow eyes or skin, white or gray stools, and abdominal tenderness was requested from the interviewees. Positive information regarding the first or second item, together with an associated illness of plausible

duration, was considered a probable case of infectious hepatitis. Only cases diagnosed and verified by physicians were classed as definite cases of infectious hepatitis.

The portion of the city in which the survey

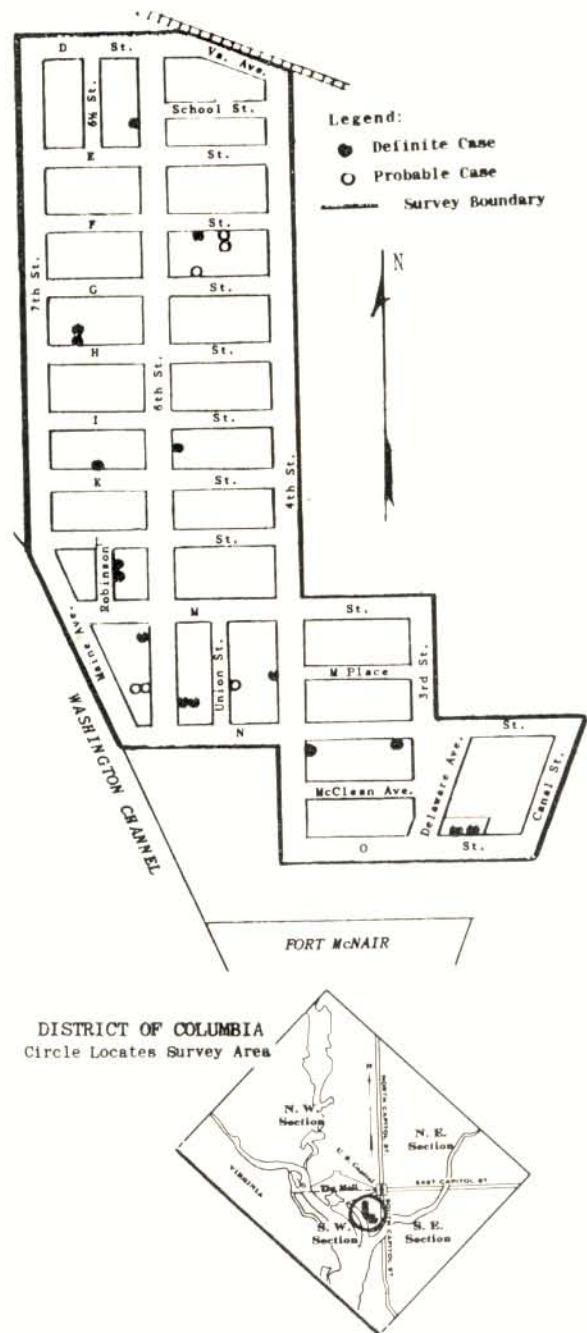


Figure 1. Distribution of infectious hepatitis cases within survey area, Washington, D. C., November 25, 1954–March 10, 1955

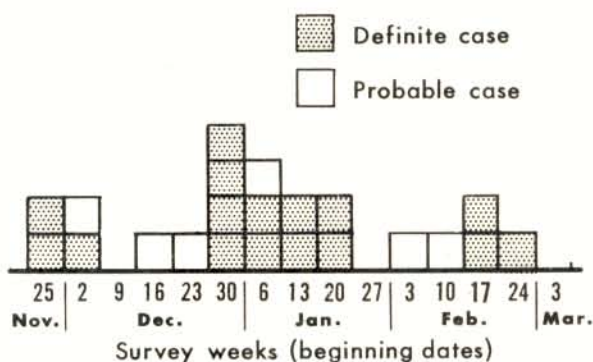
area is located is of low socioeconomic status and is characterized as "blighted" to "slum." Most of the buildings are old, two-story, brick, row houses that have been converted into tenements. There are small stores and shops on some of the streets, but no large industrial plants. The area is primarily residential and is inhabited by both the Negro and white races, with Negroes predominating.

The survey area had a population density of approximately 43,200 persons per square mile. Age, race, and sex distributions of the surveyed population are given in table 1. Of the 1,579 households, 27.4 percent had outdoor plumbing fixtures. The households served by outdoor plumbing comprised 1,608 persons, 29.2 percent of the surveyed population.

Infectious Hepatitis

Sixteen definite and six probable cases of infectious hepatitis occurred in the survey area between November 25 and March 10. There was no correlation between incidence and outdoor plumbing. On the contrary, there was strong evidence that the outbreak was propagated by contact. This was demonstrated by a comparison of two ratios: (a) the number of infected persons reporting contact to the total number of infected persons and, (b) the number of noninfected persons reporting contact to the total number of noninfected persons. These ratios expressed as percentages proved to be

Figure 2. Incidence of infectious hepatitis in survey area, Washington, D. C., November 25, 1954-March 10, 1955



23.9 and 0.1, respectively; thus, the rate of contact was 239 times as great for those who had the disease as for those who did not.

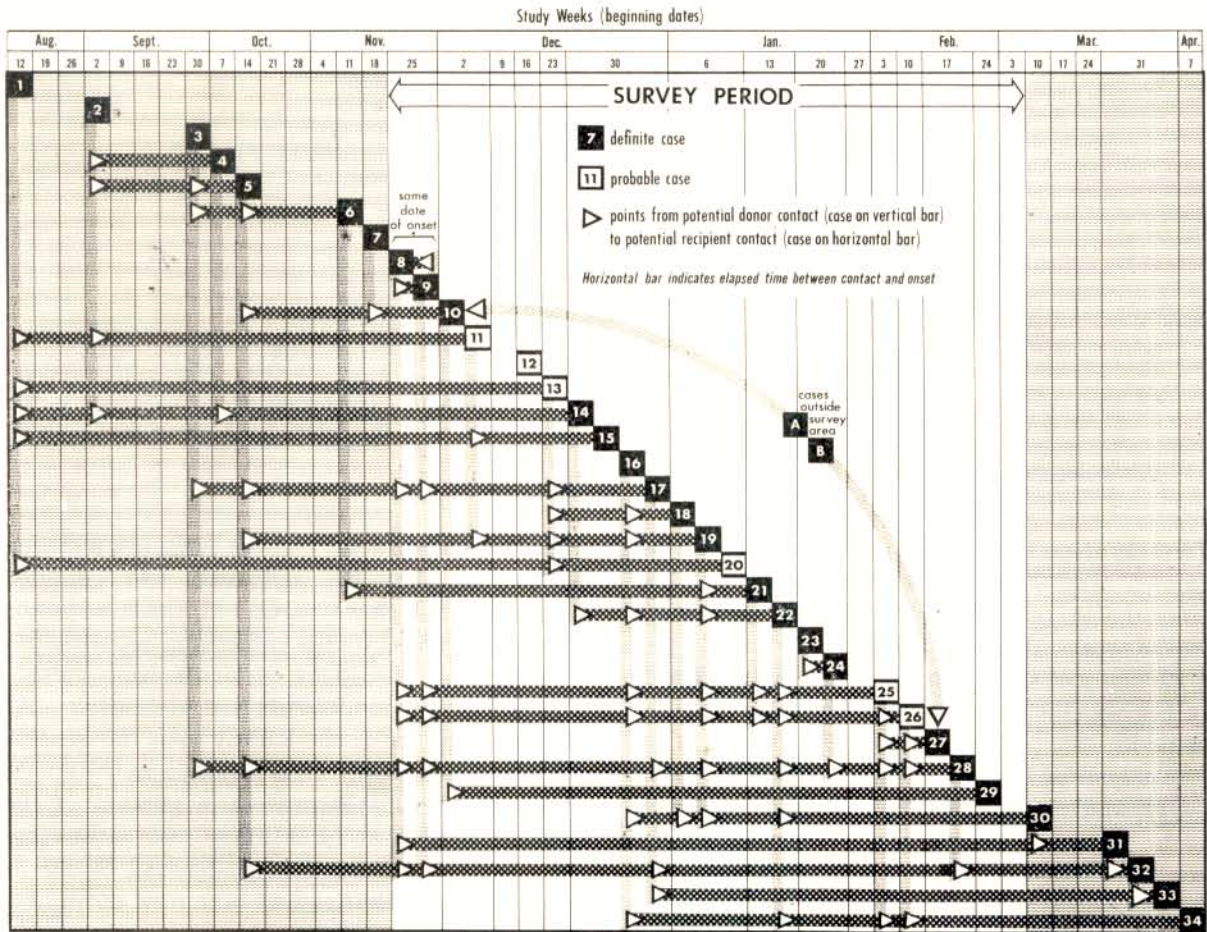
The distribution of the cases by date of onset is given in figure 2. It is typical for contact spread. Distribution of the cases by location is shown in figure 1.

The most striking fact about the outbreak is that it was almost completely confined to white children under 15 years of age. Fourteen of the 16 definite cases and 2 of the 6 probable cases occurred among that group. The number of white children under 15 years of age in the survey area was 620. Thus, the attack rates for that group for the survey period were 2,260 per 100,000 for definite cases and 2,900 for definite plus probable cases.

Table 1. Age, race, and sex distribution of the surveyed population

Age (in years)	Total	White				Negro				Race not stated			
		Total	Male	Female	Sex not stated	Total	Male	Female	Sex not stated	Total	Male	Female	Sex not stated
Total	5,519	2,047	995	1,039	13	3,216	1,433	1,779	4	256	130	125	1
Under 5	719	208	105	102	1	476	238	238	0	35	16	19	0
5-9	710	242	111	131	0	440	214	226	0	28	15	13	0
10-14	489	170	93	77	0	303	134	169	0	16	10	6	0
15-24	656	233	97	136	0	398	152	246	0	25	13	12	0
25-34	657	245	126	119	0	375	145	230	0	37	18	19	0
35-44	758	284	135	149	0	441	181	260	0	33	14	19	0
45-54	595	224	116	108	0	336	151	185	0	35	20	15	0
55-64	414	184	94	90	0	213	110	103	0	17	9	8	0
65 and over	329	168	82	86	0	147	69	78	0	14	6	8	0
Not stated	192	89	36	41	12	87	39	44	4	16	9	6	1

Figure 3. Chain of "potential contacts" for the 34 cases of infectious hepatitis cases occurring in the survey area, August 12, 1954–April 14, 1955



The crude attack rate for definite cases was 290 per 100,000 population for the 15-week period; it was 400 for definite plus probable cases. Annual attack rates for reported infectious hepatitis cases in 14 major cities in the United States in 1954 ranged from 5.4 to 141.0 per 100,000 population. Of course, attack rates based on reported cases cannot be compared with rates based on an intensive survey. They are included only to indicate the general level of incidence of the disease.

Four secondary cases occurred during the survey period, 2 definite and 2 probable cases. Eighty-two persons were risks to secondary infections (members of a household in which a primary case occurred) for definite cases, and 105, for definite or probable cases. Thus, the secondary attack rates for the survey period

were 24.4 per 1,000 for definite cases and 38.1 per 1,000 for definite plus probable cases. The ratios of secondary to primary attack rates were 9.6 and 11.7 for definite and definite plus probable cases, respectively. Three of the four secondary cases occurred within 2 weeks of the primary cases. The fourth occurred 12 weeks after its primary case.

In light of the findings of the case-finding survey, the health department made a case-and-contact survey shortly thereafter. An additional 12 definite cases were discovered to have occurred within the bounds of the survey area from August 12 through April 14, giving totals of 28 definite cases and 34 definite plus probable cases for this period. No rates, of course, can be inferred from these numbers since it is unlikely that they include all cases occurring be-

Table 2. Chronology of infectious hepatitis cases by communal place, September 2, 1954–April 6, 1955

Communal place	Week number																																	
													Survey period																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			
School A	2				4												{14}																	
School B							5					8																						{31}
School C																¹ 13	17																	{32}
Club A																¹ 13																		{33}
School D																	16	{18	22															
Club B																																		

¹ Probable case.

fore or after the survey period. The earliest known case associated with the outbreak was that of a woman who worked in a grocery store in the area. While in the store, she had contact with many of the children in the neighborhood; in her case history, she cited four who later became ill.

Analysis of the contact information showed a surprisingly complete chain of "potential contacts" within the limited survey area. A person was considered to be a potential contact if he was named as a contact by a person who had a definite or probable case of infectious hepatitis and if he too was found to have had a definite or probable case. To elicit the maximum contact information from the interviewees, questions were asked regarding persons in the following categories: acquaintances who had had infectious hepatitis since September 6; other patients and their contacts known personally by the interviewee (usually schoolmates); visitors to the patient during his illness; persons associated with the patient in the home environment within 3 days before or 3 days after date of onset. The potential contact chain for the 34 definite and probable cases is shown in figure 3.

For 27 of the 34 cases, the contact information revealed one or more possible sources of infection among members of the group. Only two of the potential donors of the disease lived out-

side the survey area. These facts are a strong indication that the outbreak was confined largely to the survey area. A check with the schools attended by the infectious hepatitis patients, which also draw students from outside the survey area, supported this contention. As shown in figure 1, the survey area has several isolating boundaries: the railroad on the north, the Washington Channel on a portion of the western border, and a military reservation just beyond the southern limit. Several blocks to the east, the buildings had been torn down in a slum clearance project.

When the applicable cases were grouped chronologically by communal places (schools or clubs of which two or more members had the disease), table 2 resulted. These data show that the disease progressed in a fashion typical of contact. Twenty-three of the thirty-four patients were members of six such groups. Intracommunal group contact can be traced by referring to figure 3.

According to available figures, 9.0 to 9.9 percent of all dwelling units in an area similar to, and including, the survey area provide less than 39 square feet of sleeping space per person. For the 30 households in which infectious hepatitis occurred, the percentage was 16.6. For the 6 households in which secondary cases occurred, the figure was 50 percent. (Two secondary cases occurred prior to the period covered by the original survey.) This indicates, as

might be expected, a correlation between incidence of secondary cases and crowding.

All the cases among school children occurred in the white population although the schools are not segregated. Only two definite cases and one probable case, all in persons over 27 years of age, occurred among the large Negro population of the area. These facts arrest attention, but there are two possible explanations. First, classroom contact may not be close enough for spread of the disease, which may take place in more intimate, and still generally segregated, extracurricular activity groups. Second, jaundice is more difficult to recognize and to diagnose in Negroes than in whites. The possibility that the diagnosis and treatment facilities available to the two groups were unequal is not supported by records for the medically indigent of the area.

Diarrhea

Fifty-eight persons had diarrhea during the 15-week survey period, November 25 to March 10, a crude attack rate of 1,050 per 100,000 population. None of these persons knowingly had either infectious hepatitis or typhoid fever during that period. With the exception of the initial outbreak of 7 cases, none of the cases were attributable to outdoor plumbing. On the basis of appropriate population adjustment, diarrhea attacked four times as many whites as Negroes. No explanation for this has been evolved.

The secondary attack rate for diarrhea was 134 per 1,000 exposed persons in the surveyed population. The ratio of the secondary attack rate to the primary attack rate was 15.7, indicating that intrafamilial contact was a potent factor in the spread of this disease.

Typhoid Fever

No cases of typhoid fever occurred during the period covered by the survey. However, the surprisingly large number of 74 persons reported that they had had typhoid fever at some time in the past. Of these, 40.3 percent were served by outdoor plumbing at the time of the survey, as compared with 29.2 percent for the total population. Since many of the 74 had typhoid fever in other homes or even in other

cities, these figures do not indict the plumbing as the source of their disease, but they are of epidemiological significance from the standpoint of typhoid fever carriers.

A check of all available typhoid fever registers in the department of public health yielded records on only 5 of the 74 persons. They were listed as noncarriers. But what about the remaining 69, many of whom live in homes with outdoor plumbing? Furthermore, the finding of these 74 persons, coupled with a knowledge of plumbing conditions in similar areas, implies that there are a large number of persons in the city who have had typhoid fever and who are currently living in dwellings served by outdoor plumbing. That carriers among them pose a real threat is suggested by the fact that during the past 10 years an annual average of 14 cases of typhoid fever has been reported in the District of Columbia.

A 7-year-old girl and 5- and 7-year-old sisters living a block away from her made up the group of three typhoid fever cases reported in the fall of 1954. None had drunk any water other than from the municipal supply within 30 days prior to onset of the disease. The first girl became ill on September 29. She gave a history of contact with the two sisters within 3 days of that date. The other 7-year-old girl became ill on October 8, and her sister, on November 21.

The mother and a relative of the first of the girls had typhoid fever several years ago. Stool specimens from both had been examined in October 1954 and found to be negative for organisms of the *Salmonella* or *Shigella* groups. A test of a specimen from the relative in August 1955 was also negative.

Both households in which the three typhoid fever cases occurred have outside plumbing, and general household sanitation is very poor.

Summary

Circumstantial evidence suggested that contamination of the water supply through outdoor plumbing was responsible for the spread of infectious hepatitis, diarrhea, and typhoid fever in a small area of Washington, D. C., in late 1954 and early 1955. Investigation showed that, although one outbreak of diarrhea was

probably waterborne, contact was the major factor in most cases of the three diseases.

The infectious hepatitis was confined almost entirely to white children under the age of 15 years. The rate of personal contact with prior cases was significantly higher for persons who had the disease than for those who did not. A nearly complete chain of contact among the patients was traced within the survey area.

Data on sleeping space per person indicated a relation between the incidence of secondary cases of infectious hepatitis and crowding.

An unexpectedly large number of persons who had once had typhoid fever were found in the survey area. Poor sanitary and plumbing conditions, as well as contact, were associated with three cases of typhoid fever reported in the fall of 1954.

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Details of the study plan and procedures and the forms used in the surveys are available from the authors.

REFERENCES

- (1) National Research Council, Sanitary Engineering Committee: Report on cross-connections. *J. Am. Water Works A.* 37: 427-441, May 1945.
- (2) Croft, H. P.: Cross-connections causing illness. *J. Am. Water Works A.* 40: 1129, October 1948.
- (3) Fraser, R.: A study of epidemic catarrhal jaundice. *Canad. J. Pub. Health* 22:396-411, August 1931.
- (4) Hallgren, R.: Epidemic hepatitis in the county of Vasterbotten in northern Sweden. *Acta. med. Scandinav. Supp.* 140, pp. 1-104 (1942); 115: 22-39 (1943).
- (5) Gauld, R. L.: Epidemiological field studies of infectious hepatitis in the Mediterranean Theater of Operations. *Am. J. Hyg.* 43: 255-272, May 1946.
- (6) Olin, G.: A hepatitis epidemic presumably spread by water. *Acta. med. Scandinav. Supp.* 196, pp. 381-391 (1947).
- (7) Neefe, J. B., and Stokes, J., Jr.: An epidemic of infectious hepatitis apparently due to a waterborne agent. *J. A. M. A.* 128: 1063-1075, Aug. 11, 1945.
- (8) Tucker, C. B., and Farrell, R. P.: An outbreak of infectious hepatitis apparently transmitted through water. *South. M. J.* 47: 732-740, August 1954.



No Proof of Actual Harm Required In Water Pollution Abatement Action

The Appellate Court of Illinois recently held that, under a statute which defined pollution as including the "alteration of the physical, chemical or biological properties of water," the discharge by a municipality of untreated sewage into the Big Muddy River was subject to abatement by order of the Illinois State Sanitary Water Board on proof that such discharge adversely affected bacterial life normally present in the water. There was also testimony that the sewage discharge resulted in conditions detrimental to fish life.

The court rejected the argument that the board had no power to act except to abate a common law nuisance or without at least a showing of actual harm to fish or of human illness. Such restrictions, the court held, al-

though applicable to private suits, could not limit the board's powers to prevent pollution before actual harm resulted.

This is the first reported case involving the definition of "pollution" contained in the "Suggested State Water Pollution Control Act" (published by the Public Health Service in 1950), which was closely followed in the Illinois statute. *City of Murphysboro v. Sanitary Water Board of Ill.* 134 NE 2d 522 (4th Dist., Ill., 1956).

The "Suggested State Water Pollution Control Act" was endorsed by the Council of State Governments and recommended to the States in the council's "Suggested State Legislation; Program for 1951" issued in November 1950.