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A WATERBORNE OUTBREAK OF INFECTIOUS HEPATITIS IN A SMALL MARYLAND TOWN[1]

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The causative agent of infectious hepatitis has not been isolated, techniques for immuno-diagnosis are not available, and suitable experimental animals have not been discovered. Much of the natural history of the disease thus remains a mystery. Present knowledge is largely derived from experiments with human volunteers and from epidemiologic inferences. These methods have provided the foundation for the generally accepted hypothesis that infectious hepatitis can be transmitted by drinking water.

There are many reports of hepatitis epidemics in which water is implicated as the vehicle of transmission, and a recent paper suggests that water may even be involved in the endemic occurrence of the disease in this country (1). Few of these studies have been based on a defined population or have had adequate controls. Most have dealt only with cases, or with cases and population estimates derived from decennial census data.

An outbreak of hepatitis in Sharpsburg, Washington County, Maryland in 1966 offered an unusual opportunity to collect more complete information. The cases occurred in an easily delineated population, homogeneous in many respects but exposed to a variety of sources of drinking water. An investigation clearly indicated that one of these water sources was associated with, and probably responsible for, the outbreak.

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Description of the area

Washington County is in the portion of western Maryland known as the Appalachian province. Most of the county lies between the Blue Ridge and Allegheny Mountains in the Great Limestone Valley (which continues to the south as the Shenandoah Valley). The total population of the county in 1963 was 91,909 according to a private census and survey conducted jointly by the Johns Hopkins School of Hygiene and Public Health, the National Cancer Institute and the Washington County Department of Health. The principal city and county seat is Hagerstown, with a population of 35,340 in 1963.

The town of Sharpsburg is located 12 miles south of Hagerstown. It lies in a shallow depression surrounded by field-crop and pasture land. Surface drainage is through a narrow defile in the southeast corner of the town. Antietam Creek runs to the east of Sharpsburg, and the Potomac River is a few miles to the west and south. Geologically, the area is characterized by heavy clay soils overlying dolomite and limestone.

During 1966 there were over 800 persons living in nearly 270 households within the town limits. Six individuals were Negroes. Median educational attainment of heads of households as determined by the 1963 census was 8 grades of school. The citizens of Sharpsburg are, for the most part, working-class people employed in skilled and semi-skilled positions in industries in or near Hagerstown. There is no industry at Sharpsburg. The Antietam National Battlefield Site, on which was fought one of the bloodiest battles of the American Civil War, is adjacent to the town, and attracts several thousand visitors each year.

Just outside the town is an elementary school which serves Sharpsburg and the surrounding countryside. Junior- and senior-high-school students are transported by bus into Boonsboro, 6 miles away.

Many of the houses in Sharpsburg are over 100 years old. Forty per cent of them have no inside plumbing and rely on privies for excreta disposal. Houses with inside toilets use septic tanks or cesspools. There is no municipal sewerage system.

The community also lacks a municipal water system, and the water sources of the households are varied. Some collect rainwater from their roofs and store it in underground cisterns. These cisterns may be lined with brick, stone, concrete or wood. Their capacity varies from 500 to 10,000 gallons; most hold about 1,000 gallons. Many who depend on cistern storage for their water supply do not collect any rainwater, but pay to have water hauled by tank truck from other sources and pumped into their cisterns. These other sources include the municipal water systems of two nearby communities, one of which is chlorinated spring water, and the other treated water from the Potomac River.

A major source of water since the founding of the town is the "Big Spring", located in the southeast quadrant of Sharpsburg. The spring is partially enclosed by stonework which affords slight protection against surface contamination. Local sewage disposal practices combined with the underlying limestone also make contamination likely. Spring water was examined for coliform organisms regularly until 1955, but this was discontinued because there invariably was heavy contamination. High coliform counts were still found on subsequent tests in August, 1966 and

March, 1967. In spite of these findings, made public by a succession of warning signs posted at the spring, water was piped directly from the Big Spring into a few homes, the local market, a sandwhich shop, the Masonic Temple and the Community Hall. A small chlorinator was used in the sandwich shop in 1966. Most users of Big Spring water, however, have it delivered to their cisterns by tank truck without chlorination or other treatment.

Other water sources used by the people of Sharpsburg include deep and shallow wells, other springs in and out of town, and commercially bottled water. Some use a combination of two or more sources.

Method of study

The investigation was begun in October, 1966. It was primarily a house-to-house survey employing physician-conducted interviews. The interviews were loosely structured, requiring about 20 minutes for completion. The household interview form was patterned after the Hepatitis Household Form, Public Health Service 4.100A (CDC) Rev 6-59. For each case of hepatitis, an Individual Case Form, Public Health Service 4.100B (CDC) Rev 6-59, was completed. Interviews were obtained from 96 per cent of the households in the town, yielding information on 97 per cent of the population.

To qualify as a case, a clear history of generalized or scleral jaundice was required, together with other characteristic signs, symptoms and clinical course. The diagnoses were confirmed by the patients' physicians in most instances. Of the 7 unconfirmed cases, one patient failed to consult a physician altogether and another had done so only after the signs and symptoms of the illness had subsided. Five were attended by a physician whose death before the survey resulted in his records being unavailable for examination. Where laboratory findings could be reviewed they were found to be characteristic of infectious hepatitis. No attempt was made to identify anicteric cases because the outbreak had occurred 5 to 6 months preceding the survey.

Table 1

Clinical manifestations of infectious hepatitis in 44 cases occurring in Sharpsburg, Maryland, 1966

Sign or symptom	No.	%
Jaundice		
Generalized	37	84
Scleral only	7	16
Nausea, anorexia	38	86
Dark urine	37	84
Malaise	35	80
Fever	33	75
Fatigue	33	75
Abdominal discomfort	31	70
Vomiting	30	68
Light stools	15	34

Results and discussion

A total of 44 cases of icteric hepatitis was identified among residents of Sharpsburg as occurring during 1966. A summary of the clinical manifestations is presented in table 1. The distribution of signs and symptoms is entirely characteristic of hepatitis. The cases occurred in 30 households—20 with one case each, 6 with two cases and 4 with three cases.

The total attack rate for Sharpsburg in 1966 was 5.2 per cent, the same for males and females. There were no fatalities. The cases in Sharpsburg occurred toward what appears to the climax

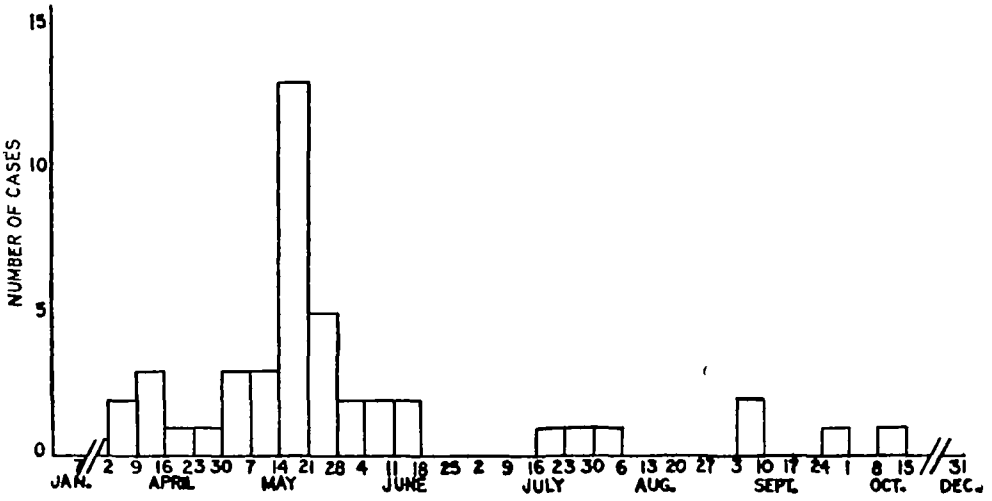

FIGURE 1. Distribution of cases of infectious hepatitis by week of onset, Sharpsburg, Maryland, 1966.

of a county-wide epidemic. For the years 1962 through 1966, the numbers of cases reported for Washington County were 4, 1, 52, 106 and 132, respectively. Were it not for the Sharpsburg outbreak, the county incidence would have declined in 1966. About 20 cases would probably have remained unknown to the health department if this outbreak had not encouraged a more intensive case-finding effort. Preliminary reports for the early months of 1967 suggest that the county epidemic has in fact subsided.

The distribution of cases in Sharpsburg by week of onset is shown in figure 1. The peak of the epidemic occurred in the week of May 15–21, with 13 cases, and 37 of the 44 cases occurred between April 3 and June 18. This 11-week period will be considered as the epidemic period. The subsequent analysis will be limited to the 37 cases occurring during that interval, and to the population living in Sharpsburg during the first 6 months of 1966.

The location of the cases in the town of Sharpsburg is shown in figure 2, which also shows the location of the Big Spring. Although scattered, the cases show a tendency to cluster in the vicinity of the Big Spring. However, when the element of time is taken into account, there is no evidence of radial spread.

Hepatitis attack rates according to drinking water source are presented in table 2. Members of a household could have different sources of drinking water, but usually this was not the case. The highest attack rates were among persons using Big Spring water solely or in combination with other sources. Some individuals were probably exposed to Big Spring water without their knowledge, perhaps at a neighbor's house or a social gathering, or had forgotten such exposures by the time of the survey. Nor can the possibility be excluded that some households ordering city water or other spring water may have received Big Spring water occasionally without

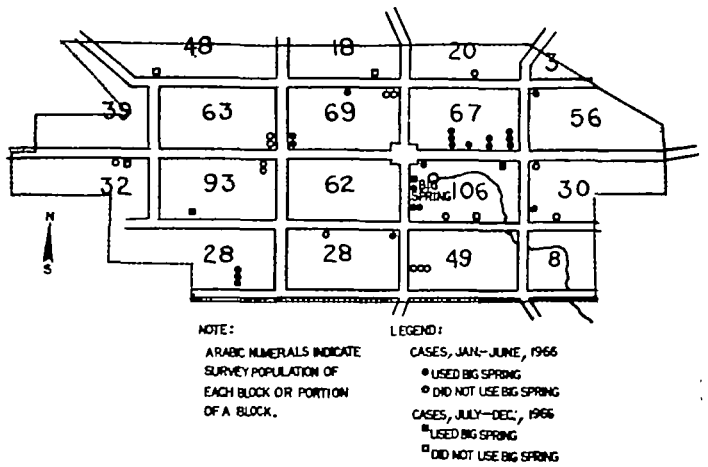

FIGURE 2. Location of cases of infectious hepatitis in Sharpsburg, Maryland by period of onset and source of drinking water.

TABLE 2

Attack rates of infectious hepatitis by source of drinking water, Sharpsburg, Maryland, January–June, 1966

Source of drinking water	Population	Cases	
		No.	%
A. One source only			
Big Spring only	76	12	15.8
City water only	50	3	6.0
Shallow well only	86	3	3.5
Deep well only	167	4	2.4
Rainwater only	146	2	1.4
Other only	52	2	3.8
B. Combinations with Big Spring			
Rain and Big Spring	74	5	6.8
Other combinations with Big Spring	44	5	11.4
C. Combinations without Big Spring			
Rain and city water	73	0	0
Other combinations without Big Spring	20	1	5.0

their knowledge. The fact that the 3 cases among persons claiming to have used only city water occurred in a single household within a period of 2 weeks is consistent with this possibility.

TABLE 3

Age-specific attack rates among persons who did and did not use Big Spring, Sharpsburg, Maryland, January–June, 1966

Age in years	Used Big Spring			Did not use Big Spring		
	Population	Cases		Population	Cases	
		No.	%		No.	%
0–4	24	0	0	42	0	0
5–9	19	3	15.8	45	1	2.2
10–14	14	5	35.7	44	5	11.4
15–19	20	2	10.0	47	3	6.4
20+	117	12	10.3	416	6	1.4
All ages	194	22	11.3	594	15	2.5

Total and age-specific attack rates are shown in table 3 for persons who used Big Spring water alone or in any combination, and for those who stated that they had not used Big Spring water. The total attack rate among those who drank Big Spring water was 11.3 per cent, and among those whose drinking water came solely from other sources was only 2.5 per cent. Total attack rates among other populations exposed to water supplies thought to

have been contaminated with the agent of infectious hepatitis are presented for comparison: Delhi, India, 2.1 per cent (2); Curwensville, Pennsylvania, 5.8 per cent (3); a resort hotel, Austria, 12 per cent (4); and Daviess County, Kentucky, 36 per cent (5).

In both those exposed and those unexposed to Big Spring water, the highest attack rates are in the 10–14 year age group, 36 per cent among the exposed and 11 per cent among the unexposed. Among unexposed adults, the rate is low, only 1.4 per cent, while among exposed adults, it remains relatively high, 10 per cent. The pattern of age-specific rates among the exposed is similar to those observed in hepatitis epidemics attributed to a common vehicle; among the unexposed it resembles the pattern seen in the more usual circumstances where person-to-person spread of the disease is believed to occur (6).

Because the exposed and unexposed populations differed with respect to age composition, the attack rates were adjusted to the total population by the direct method. The age-adjusted attack rate among those using Big Spring was 11.7 per cent, and among those not using it, 2.5 per cent. There is more than a fourfold increase in risk associated with drinking Big Spring water.

Although the shape of the epidemic curve (figure 1) is compatible with an outbreak resulting from common-vehicle transmission, its duration is too long to be consistent with exposure lasting for only a few days. The interval between the first and last case—76 days—is much longer than the range between the commonly accepted minimum and maximum incubation periods, 15 and 50 days, respectively (7). Although a marked prolongation of the incubation period has been reported for one waterborne outbreak (2), a more reasonable assumption to account for the increased interval is that Big Spring water contained the agent of infectious hepatitis continuously or intermittently over a period of several weeks. Cases resulting from person-to-person spread may also have caused some prolongation of the epidemic curve. However, aside from the fact that 10 of the 13 cases occurring in the week of May 14 admitted the use of Big Spring water, there are no significant differences in the temporal distribution of cases with and without a history of drinking water from this source.

It was not possible to identify a source case for this epidemic. Hepatitis was present elsewhere in the county during the early spring of 1966. Many privies and cesspools might have contaminated the Big Spring through underground channels in the limestone. Several were tested with fluorescein early in 1967, but no trace of the dye appeared in the Big Spring. An undocumented outbreak of diarrheal disease is said to have occurred in Sharpsburg about the last week in March, 1966, consistent with the possibility of new or increased contamination of the Big Spring at about that time. Similar episodes have heralded the onset of other waterborne hepatitis epidemics (6).

With the long history of contamination of the Big Spring, the question arises of previous exposure to hepatitis from this source. Several survey respondents stated that an outbreak of illness characterized by jaundice had occurred in Sharpsburg in 1954. In that year there was an increase in reported infectious hepatitis in the county. Forty-five cases were reported to the Washington County Department of Health in

1954 compared with an annual average of four cases during non-epidemic years. From available records it was not possible to determine whether any of the reported cases were from Sharpsburg. If a significant outbreak occurred in the community in 1954, the resultant immunity in those then having the disease would be expected to protect them from hepatitis during the 1966 epidemic. This would be reflected in a lower attack rate among those who were residents of Sharpsburg in 1954 than among those who moved into the town after that year. However, the attack rates during 1966 were essentially the same for short-term and long-term residents. Examinations of the data stratified by whether individuals used or did not use Big-Spring water does not alter this finding, nor is it changed by adjustment for differences in age composition. It was concluded, therefore, that the 1954 epidemic had not had a significant impact on the current population of Sharpsburg.

No relationship of method of excreta disposal with hepatitis attack rates was found. Persons who drank Big Spring water had higher attack rates regardless of the type of toilet facility used (table 4).

TABLE 4

Attack rates of infectious hepatitis among persons who did and did not use Big Spring, by type of toilet facility, Sharpsburg, Maryland, January–June, 1966

Type of facility	Used Big Spring			Did not use Big Spring		
	Population	Cases		Population	Cases	
		No.	%		No.	%
Inside toilet	130	15	11.5	358	12	3.4
Privy	64	7	10.9	236	3	1.3

TABLE 5

Attack rates of infectious hepatitis among persons who did and did not use Big Spring by school attended, Sharpsburg, Maryland, January–June, 1966

School attended	Used Big Spring			Did not use Big Spring		
	Population	Cases		Population	Cases	
		No.	%		No.	%
Sharpsburg Elementary	18	4	22.2	56	4	7.1
Boonsboro Jr. High School	7	2	28.6	15	1	6.7
Boonsboro Sr. High School	14	3	21.4	33	4	12.1
Not in school	149	13	8.7	474	6	1.3
Other or not stated	6	0	0	16	0	0

A contact history was obtained for each case. For purposes of the survey, a close contact was defined as a person who lived in a household with a case or had intimate or prolonged association with a case, and a casual contact as person whose association with a case was of short duration, indirect and not intimate (such as a contact at school only). In households with multiple cases, the interval between the onsets of the first and last cases varied from 0 to 13 days, and in most instances was 7 days or less. Because this is less than the minimum incubation period for infectious hepatitis, it is believed that there were no secondary household cases, or with allowances for historical inaccuracies, only one or two at most. There were only 3 cases with a history of close contact other than household and 7 with a history of casual contact. There was essentially no difference in contact experience among the cases who did and did not use Big Spring water.

The occurrence of hepatitis was not associated with school attended, as shown in table 5. The overall rates were

highest among junior- and senior-high-school students, and much higher among students from Sharpsburg than among their schoolmates who lived elsewhere. In Boonsboro Senior High School, for example, the attack rate among students from Sharpsburg was 14.9 per cent compared to 0.3 per cent among other students. During 1965, hepatitis was present in the area served by the Boonsboro High Schools without affecting Sharpsburg residents. These findings strongly indicate that school contacts were not important in this outbreak of hepatitis.

Churches afford another important source of extra-household contacts, particularly in small towns. Most of the residents of Sharpsburg attend one of the 5 churches in town. The attack rates according to church attended are shown in table 6. The highest total attack rate was found among those attending Church A, and in this church those who denied drinking Big Spring water had a slightly higher attack rate than those who drank it. This is the only instance in which use of Big Spring water was not associated with increased risk of hepatitis. On subsequent inquiry it was ascertained that Church A does not provide a drinking water facility in the church building. On April 20, a Congregational supper was held at the Community Hall, at which Big Spring water was served. However, only one case among the persons who said they did not use Big Spring water occurred within a reasonable period following this supper. Attempts to ascertain if drinking water was brought in to Church A for use during Sunday School and church services were not successful, largely because by this time the topic of drinking water had become charged with strong emotional overtones.

TABLE 6

Attack rates of infectious hepatitis among persons who did and did not use Big Spring by church attended, Sharpsburg, Maryland, January–June, 1966

Church attended	Used Big Spring			Did not use Big Spring		
	Population	Cases		Population	Cases	
		No.	%		No.	%
A	28	2	7.1	48	5	10.2
B	27	4	14.8	67	3	4.5
C	18	1	5.6	86	4	4.7
D	22	1	4.5	122	1	0.8
E	9	0	0	95	0	0
Other, none, not stated	90	14	15.6	176	2	1.1

Other potential sources of exposure to Big Spring water are the homes of friends and relatives. It was noted that in these 5 congregations the attack rates among those who did not use Big Spring water were closely related to the proportion of the church attenders who did use Big Spring water in their homes. Members of Church A in visiting their church friends and relatives would thus be more likely to be offered Big Spring water than members of Church E in making similar visits. There is no other evidence to support this speculation as to the source of hepatitis among persons who did not use Big Spring water at home.

Person-to-person spread cannot be entirely excluded in this epidemic, and it may indeed explain some of the anomalous findings. Its role, however, appears to have been minimal. No secondary household cases can be identified, and exposure at school seems unimportant. The only other major social organizations in town were the churches, and although the attack rates did vary markedly from church to church, in only one was the rate higher among non-

TABLE 7

Attack rates of infectious hepatitis among persons who did and did not use Big Spring by milk supply, Sharpsburg, Maryland, January–June, 1966

Dairy	Used Big Spring			Did not use Big Spring		
	Population	Cases		Population	Cases	
		No.	%		No.	%
A	74	9	12.2	173	2	1.2
B	33	3	9.1	129	1	0.8
C	10	1	10.0	63	0	0
Other, not stated	77	9	11.7	229	12	5.2

users of Big Spring water than among users.

Milk, prepared food, raw and inadequately cooked shellfish, and injections have been implicated as common-vehicle sources of infection in previous hepatitis outbreaks. None of these can be associated with this epidemic. Most of the milk consumed in Sharpsburg is provided by three large dairies which are also the main suppliers for the rest of the county. No respondents admitted the use of raw milk. Attack rates according to source of milk, shown in table 7, do not vary significantly when stratified by history of having used or not used Big Spring water. No grocery or market was patronized more by the cases than the non-cases. The only large public gathering at which food was served was the annual Fireman's Parade and Picnic, but this took place on May 30, *after* most cases had occurred. The only church supper was the one held by Church A and described above. In this part of Maryland, fresh shellfish are not readily available. Only six cases had received injections during the six months before illness, and the sources of the injections for each case were different.

A comprehensive study of the effect of gamma globulin on the course of the epidemic was not attempted. On April 23 and 25, gamma globulin was given to 80 per cent of the students at Sharpsburg Elementary School. Other residents received it from their private physicians or from the Washington County Department of Health. In all, 15.8 per cent of the population (excluding cases) received gamma globulin, usually in a dose of 0.05 ml per pound of body weight. A slightly smaller proportion of Big Spring users (12.8 per cent) than of those using other water sources (16.9 per cent) received gamma globulin during the epidemic period. Six individuals developed hepatitis after receiving gamma globulin, all of them within 10 days after the injection, and four of the six within 3 days of receipt of gamma globulin. It now appears—after the fact—that gamma globulin was given too late to have had any marked effect on the course of the epidemic, except that it may have been given to the elementary school students in time to have prevented a few cases among them.

SUMMARY AND CONCLUSIONS

During 1966, 44 cases of icteric hepatitis occurred in the town of Sharpsburg, in Washington County, Maryland. Of these cases, 37 occurred within an 11-week period, with a distribution by time of onset that strongly suggested a common-vehicle outbreak.

A virtually complete house-to-house survey of the town showed that the risk of hepatitis among persons who obtained drinking water from a particular source, the Big Spring, was more than four times higher than that of persons who obtained drinking water from other sources. The Big Spring has shown evi-

dence of fecal contamination for many years. No evidence could be found to implicate other common exposures, and person-to-person spread appeared inadequate to account for the majority of cases.

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