Differentiation of Sources in a Hepatitis Outbreak

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AN OUTBREAK of infectious hepatitis occurred during the period from July 1963 through May 1964 in a relatively circumscribed U.S. village complex of 9,600 people. Preliminary investigation revealed contaminated shellfish, polluted water, milk, and personal contacts to be suspect in transmission of the disease.

Lack as yet of readily applicable laboratory methods for isolation and identification of hepatitis virus places the burden of establishing probable transmission pathways in such outbreaks upon epidemiology. In the epidemiologic approach, judicious use of inferential data, following collection and analysis, makes it possible to suggest, or even reveal, sources and patterns of infection with considerable confidence. Differentiation of the sources of the outbreak under study is a case in point.

Thirty-two persons were reported to have contracted infectious hepatitis during the period described. In addition, two other persons were known to have had symptoms compatible with the disease. Because these two persons had not been examined by physicians, they were not listed as having cases.

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Other than in schools, no large common gatherings of the village population were known to have occurred during the period from July 1963 to May 1964. Only two of the persons infected reported consuming raw shellfish (cases 1 and 32, table 1). None of the 32 persons with reported cases had received tranfusions within 6 months before onset of the infectious hepatitis. One 10-year-old girl (reported as having case 20) had undergone minor surgery 7 weeks before onset; three persons had received injections within 6 months before onset; one person had been visiting his dentist weekly. Of the total number with reported cases, 22 persons were 15 years old or less and 10 were more than 15. If the two persons with symptomatic but unreported cases, who were above 15 years of age, are added to the group more than 15 years old, the proportion 15 years or less who had become infected is about 65 percent. This percentage is close to the figure cited by Rhodes and van Rooyen (*1*) for infectious hepatitis in this age group.

Materials and Methods

Clustered onset dates (see chart) suggested a common source of infection, and tabulation by case appears to implicate dairy 2 in 17 of the 32 reported cases of infectious hepatitis. In the tabulation by family (to mimimize bias incurred when many persons are exposed to a single source), the role of dairy 2 is not as striking but certainly merits further consideration as a possible source of infection. The families in which

cases 13, 15, 21, and 22 occurred—families H and M—were each supplied by different dairies, but they reported, as their water source, wells known to be polluted. Four families had more than one case each.

Reported cases are listed and numbered according to date of onset of symptoms (table 1); the family, area, school, and dairy are coded for the sake of anonymity. The persons with the two symptomatic but unreported cases, 18–P and 16–S, are listed according to familial relationships rather than by date of onset. (Wherever possible, data in table 1 will not be repeated elsewhere.)

In 38 cases of infectious hepatitis associated with consumption of oysters that were reported by Lindberg-Broman (*2*), the known incubation periods between ingestion of the infectious meal and appearance of definite symptoms reached a mean of 27 days. Thirty-one of the cases (81.6 percent) had incubation periods ranging from 25 to 30 days. We noted a similar interval in our own investigation. In 25 cases (78 percent) with reasonably definite exposure times, incubation periods appeared to be from 25 to 30 days.

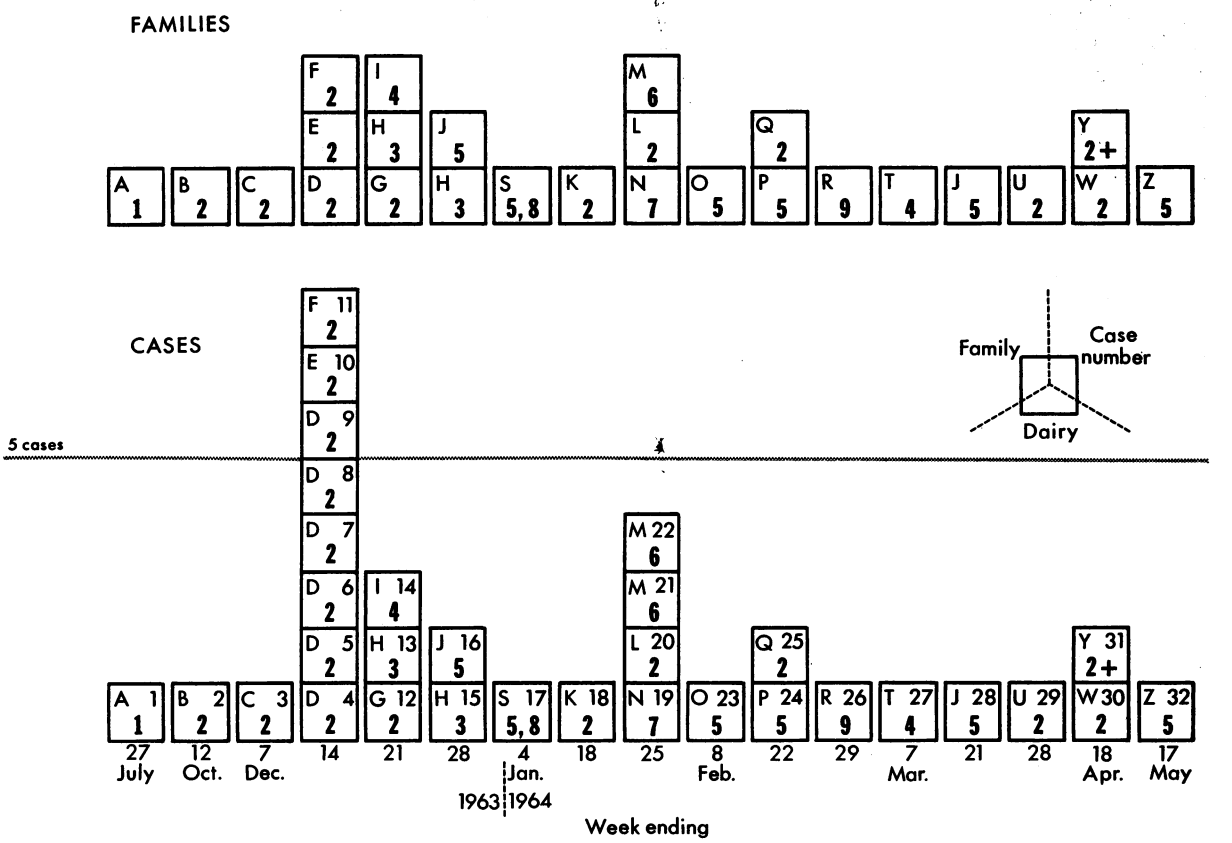
Case 1 had its onset on July 25, 1963, in a 31-year-old man approximately 25 days after he had consumed raw shellfish collected from a coastal area. Because of sewage pollution, these particular shellfish grounds had been closed to the taking of shellfish other than for bait. According to this man, however, the natives in the area had said, "Go ahead and eat them . . .

Table 1. Cases by date of onset

Case number	Family	Onset	Area	Age (years)	Sex	School and grade	Dairy	Sewage	Water
1 [1]	A	July 25, 1963	A	31	M		1		
2 [2]	B	Oct. 7, 1963	B	13	M	I—9	2	Cesspool	Well.
3	C	Dec. 5, 1963	B	10	M	H—5	2	Septic tank	Do.
4	D	Dec. 8, 1963	C	5	M	Preschool	2	Cesspool	Do.
5 [2]	D	do	C	9	M	H—4	2	Septic tank	Do.
6	D	do	C	10	F	H—5	2	do	Do.
7 [2]	D	do	C	12	F	G—7	2	do	Do.
8 [2]	D	do	C	13	F	G—8	2	do	Do.
9 [2]	D	Dec. 10, 1963	C	14	M	I—9	2	do	Do.
10 [2]	E	Dec. 11, 1963	C	7	F	H—3	2	Public utility	Public utility.
11 [2]	F	Dec. 13, 1963	B	15	M	I—10	2	Septic tank	Well.
12 [2]	G	Dec. 16, 1963	B	7	F	H—2	2	do	Do.
13	H	do	B	33	M		3	do	Well, polluted Dec. 5, 1963.
14 [2]	I	Dec. 20, 1963	B	7	F	H—2	4	Cesspool	Well.
15	H	Dec. 24, 1963	B	26	F		3	Septic tank	Well, polluted Dec. 5, 1963.
16 [2]	J	Dec. 27, 1963	B	14	M	G—7	5	Cesspool	Well.
17	S	Jan. 1, 1964	E	30	F		5, 8	Septic tank	Public utility.
18	K	Jan. 13, 1964	B	4	M	Preschool	2	Public utility	Do.
18–P [3]	K	Jan. 18, 1964	B		F				
19	N	Jan. 21, 1964	B	10	F	K—	7	Public utility	Do.
20	L	Jan. 24, 1964	A	10	F	F—5	2	Septic tank	Well.
21	M	do	B	38	F		6	do	Well, polluted.
22	M	Jan. 25, 1964	B	20	M		6	do	Do.
23 [2]	O	Feb. 8, 1964	B	22	F		5	Cesspool	Well.
16–S [4]	J	Feb. 9, 1964	B	18	F				
24 [2]	P	Feb. 16, 1964	D	10	M	H—3	5	Septic tank	Do.
25	Q	Feb. 17, 1964	B	15	F	L—	2	Public utility	Public utility.
26	R	Feb. 24, 1964	B	7	F	H—2	9	Septic tank	Well.
27	T	Mar. 5, 1964	B	33	M		4	Public utility	Public utility.
28	J	Mar. 17, 1964	B	10	F	H—4	5	Cesspool	Well.
29 [2]	U	Mar. 23, 1964	B	12	M	H—6	2		
30 [2]	W	Apr. 14, 1964	B	15	M	I—10	2		
31	Y	Apr. 15, 1964	C	18	F		Many		
32 [1 2]	Z	May 13, 1964	B	39	M	I—[5]	5	Septic tank	Do.

[1] Man had eaten raw shellfish.
[2] Nailbiter.
[3] In mother of child with case 18; mother was not examined by a physician.
[4] In sister of boy with case 16; sister was not examined by a physician.
[5] Teacher.

Infectious hepatitis cases reported during outbreak, week of their onset, families affected, and dairies patronized



everybody does!" Since the interval between ingestion of the shellfish and onset of symptoms was within the accepted incubation period for hepatitis and no other source of the disease was revealed, case 1 was tentatively classified as being associated with consumption of shellfish.

Case 2, which had its onset October 7, 1963, in a 13-year-old boy, was initially listed as "exposure unknown." For the 2 months following this date, no new cases were reported. On December 5, however, case 3, in a 10-year-old boy, was added to the list. This boy attended a different school than the 13-year-old boy, but the families of both boys obtained their milk supply from dairy 2. Cases 4 through 8 were reported 2 days later in one family, whose milk supply also was listed as coming from dairy 2. In rapid succession, cases 9 through 13 followed. All cases from 2 through 13 except case 13 occurred in school-age children using dairy 2 products. Therefore, at this time, an epidemiologic investigation was initiated to ascertain what relationship, if any, might link the ingestion of contaminated shellfish, the separate occurrence of case 2, and dairy 2 in the transmission of infectious hepatitis in the village complex.

Results

Initially, no connection appeared between case 1 and subsequent cases. Further investigation, however, revealed that the shellfish consumer (case 1) subsequently became so ill that on August 16, 1963, he was hospitalized. The man's mother and daughter and also the small brother of the 13-year-old boy (case 2 with onset October 7, 1963) accompanied him to the hospital. The mother and daughter subsequently received gamma globulin; the boy did not.

Examination of school attendance records revealed that this boy who visited the hospital on August 16 was absent from school H because of "gastrointestinal illness" 33 days after this exposure to the man with case 1. Three other

siblings were also absent on dates compatible with the incubation periods generally accepted for infectious hepatitis. Thus, four of nine children of family B, the second of whom was examined and officially reported as having infectious hepatitis (case 2), were known to have had frank illness with symptoms suggestive of the disease.

This pattern of disease occurrence is similar to that described by Paul and Havens (*3*) for family epidemics, in which one child contracts a mild case of jaundice to which little notice is paid; about a month later, another family member becomes jaundiced, and he receives greater attention. Several authorities have noted the occurrence of infectious hepatitis as a transient or inapparent illness in the young (*3–5*). Their observations lend support to the hypothesis that mild or fleeting illness in young siblings in families afflicted with infectious hepatitis was of importance in the outbreak under study. This concept, however, might not apply to certain other situations. (*5*).

An infectious link between the index case and cases 4 through 9 of family D could have been supplied by the preschool sibling of the 13-year-old with case 2. Although this preschool child was not reported as having a frank case of infectious hepatitis, he fulfills many criteria that would explain an apparently common source of infection for a preschool youngster and students in grammar and high schools. Several circumstances seemed to further enhance the importance of school contacts in the transmission of this epidemic and to reduce the importance of dairy 2. The interval between onset of cases 12 and 14 in two 7-year-old girls, was short. Both girls were in grade 2 of school H, but the family of one (with case 12) used the products of dairy 2 and the family of the other girl (with case 14) used those of dairy 4, as table 1 shows.

Some time after the bulk of the data had been collected, it was learned that seven of the children of family D, in which there were six cases of infectious hepatitis (cases 4 through 9), had been taken on a Halloween trick or treat tour by a 22-year-old woman (case 23). At one house all but one child had consumed a homemade ade-type of drink. This house had a municipal water supply, and no history of disease in members of the household could be obtained. All seven children on the tour were reportedly ill from Thanksgiving Day on with the notable exception of the child who refused the drink. The six who were ill were listed as having verified cases of infectious hepatitis early in December (table 1, cases 4 through 9). The evidence strongly suggested a common source of infection for the six children, leaving little doubt that milk from dairy 2 was not involved in the outbreak.

Analysis of the hepatitis incidence (see chart) to the week of December 14, 1963, suggested a small epidemic with a common source revolving around dairy 2. As the investigation matured, however, there were growing indications that school contacts between those with primary cases and the large D family were ample for introduction of the virus into the homes, and vice versa. In the homes, crowded, unsanitary conditions favored fecal-oral spread, and transient gastrointestinal upsets would receive little notice. Moreover, specific classroom groups in which one or more members of families B and C were distributed used assigned school toilet facilities, and—very important—the water pressure in these sanitary facilities was inadequate. All these circumstances appeared to minimize dairy 2's significance in this outbreak.

Dairy X, located in a neighboring town, supplied the school lunch program. As no untoward hepatitis incidence was revealed, however, among the clientele on its regular route, the dairy was not included in table 1 or in the chart.

No data other than those in table 1 were added until case 13 occurred. This case, in a 33-year-old man of family H, had its onset on December 16, 1963; 8 days later the illness of his wife was reported (case 15). Neither had a history of personal contact with anyone having a known case of infectious hepatitis. Their household water source, however, had been declared unsafe for drinking after a sampling by the State laboratory on December 5, 1963. During the course of the investigation, an examination of the well area revealed that their water supply constituted a drainage point for the valley, which contained septic tanks for about 10 dwellings. In addition, the cesspool of family D (cases 4–9) lay some 700 yards away, beyond a rocky ridge. It may be significant that the substratum had

been blasted to increase the water supply to the well and that this blasting was done in an area of shallow soil interspersed with ledges. Cases 13 and 15 might therefore be considered waterborne. The remaining reported hepatitis cases (cases 16–32) showed histories of personal contacts with persons in supposedly infectious states of the disease.

Discussion

Raw shellfish. The history of case 1, the length of the incubation period following the man's ingestion of the raw shellfish, and his lack of previous contact with anyone having a known case of infectious hepatitis, as well as his consumption of shellfish from an area closed because of pollution, all pointed to the contaminated shellfish as the source of infection. Hepatitis associated with shellfish may not conform to the usual phenomena seen in outbreaks of foodborne disease in which the pathogen multiplies within the food material. There is no available evidence suggesting that hepatitis virus multiplies in mollusks or other foods. Further, there is at present no way by which the ratio of virus-bearing shellfish to virus-free shellfish may be estimated from any given lot of bivalves taken from a polluted "wild" source. Although certain crude measurements of infectivity have been made, based upon given amounts of infectious human feces supplied to volunteers, the actual viral dose needed to produce infection when ingested by a susceptible person is not known (*6*). These questions also remain: If other people than the man of case 1 also ate of the quahaugs that he supplied, how many were susceptible to the infection? Among the susceptibles, did some have cases of infectious hepatitis that were not reported because of a mild course or for other reasons?

Even though further inquiry revealed that the wife and two sons of the man of case 1, as well as his sister-in-law and her family and a neighbor family, had shared in eating the suspect shellfish, no reports were received of other untoward incidents associated with this fairly extensive sampling, and shellfish association did not appear to have been further substantiated in regard to case 1.

Case 32 occurred in a teacher of school I, who had the 15-year-old boy of case 30 as a student. This teacher often used the student toilet rather than the less convenient faculty facility, and he was a nailbiter. Within the 30 days before onset of his symptoms, he had patronized several restaurants, attended an out-of-state wedding on April 25, 1964, and had eaten raw shellfish at least every weekend. He had purchased the shellfish (*Mercenaria mercenaria*, that is, quahaugs, or "hard clams" of a small size, which are called cherrystones or littlenecks) from a local supermarket. The supermarket's stock came through a reshipper who, in turn, purchased from a source which had frequently been mentioned in connection with a large epidemic of shellfish-associated hepatitis during the late winter and early spring of 1963–64 (*7*).

The market in question sells about one-half bushel of littlenecks each week in the community. If an average of a dozen people could be served from a half-bushel of these shellfish, perhaps even fewer people would have been supplied at the time of year of the outbreak. With the strong seasonal demand, larger quahaugs than usual can be marketed at this period as littlenecks, and thus there generally are fewer clams per bushel. Also, some of these shellfish may have been eaten steamed rather than on the half shell so that less uncooked shellfish would have reached the ultimate consumers. Therefore, the weekly disease-related impact of a mere half-bushel of quahaugs on a community can scarcely be measured unless it is noteworthy that the occurrence of case 32 was not accompanied by any reported cases of shellfish-associated hepatitis. In addition, the teacher's personal habits and his contacts within the incubation period of the disease with a student having a reported case seem to favor personal contact over shellfish consumption as the route of infection.

Dairy 2. Closer investigation of dairy 2 revealed a modest family operation with five employees, retailing about 1,900 quarts of pasteurized milk three times weekly in the area, or about 25 percent of the local supply. All employees had up-to-date annual health certificates, signed by a physician, attesting that they were "essentially negative" in regard to infectious diseases.

Pasteurization was by the holding vat method

(143–145° F. for 30 minutes), monitored by a recording thermometer. In processing, sufficient chlorine was added to the well water to reach 200 ppm and mixed in a vat for about 4 minutes before use. Bottles were not chlorinated after they left the washer to be filled. A laboratory report dated June 18, 1964, relating to bacteria counts from 6 quart-bottle samples, showed residual bacterial plate counts of 1,900, 1,700, 2,300, 1,600, 2,100, and 2,500. These counts are considerably higher than the accepted limit of not more than one per milliliter of capacity of the container being tested (*8*). Bottles were capped with a plastic cover that protected the pouring surfaces. Wholesale milk was sold to stores in lip-protecting paper cartons.

The dairy plant itself was fully screened. Its water source, a 45-foot drilled well with a jet pump, was found to be wholly acceptable. On May 25, 1964, a State laboratory test of the water listed the MPN of coliforms at less than 2.2; all coliform tests in 10 ml. portions were reported as negative. Other recordings differed unappreciably from those of the previous year and all were therefore graded No. 1. Waste disposal at dairy 2 was downgrade, well away from the water source. The septic tank drainage area sloped toward a fast-running stream. Of two other farms also supplying milk to dairy 2, one had no water sample report, while the water supply of the second had a State grading of No. 1 as of October 1963. A third supplier had ceased operations. Bacteria counts in 1964 tests on raw milk from dairy 2 and its milk suppliers are shown in table 2. Table 3 shows the counts for pasteurized milk and cream.

In addition to dairy 2's distribution of the bottled product, it supplied about 110 cans of milk each month for use in eight mechanical dispensers. Five of these dispensers were in geographic area B, while three served a portion of area C, where no hepatitis had been reported. Since the age groups and social groups patronizing these bulk units were rather sharply defined, none of the few persons from area C with reported cases of infectious hepatitis were likely to have been exposed by drinking milk from these dispensers. If each can of milk used in the dispensers supplied some 90 glasses and if a generous amount is allowed for two-glass customers and for coffee, at least 75 persons might have been exposed per can. Thus, some 8,250 persons per month might have been exposed—less the number of multiple exposures of regular clients.

Had milk been the vehicle of transmission of the infectious hepatitis, however, the effects on the community from a mass inoculation would most likely have produced an epidemic in which the pattern was more typical of waterborne (or milkborne or foodborne) disease outbreaks. Numerous cases would have occurred within a brief period. The outbreak under study was not, however, so explosive. Further, available records indicate that infectious hepatitis outbreaks which were considered as possibly milkborne involved raw milk. Dairy 2 sells only the pasteurized product. The discovery that phosphatase tests of this dairy had been negative for the 14 months preceding the outbreak removes reasonable doubts as to the efficiency of pasteurization in this situation (*9–11*).

Although the evidence appears to minimize the significance of the dairy in the outbreak, a question must be raised as to the reliability of the holding method of pasteurization for inactivating hepatitis virus that might reach the milk. The time-temperature ratio used in this method was 30 minutes at 142–145° F. For comparison, the following table shows results of experimental time-temperature studies of the survival of infectious hepatitis virus A and the closely related serum hepatitis B (*12, 13*).

Time-temperature ratio	*Virus A*	*Virus B*
30 minutes at 132.8° F.	Survived----	Survived.
1–4 hours at 140° F--	----------	----------
10 hours at 140° F. (with albumin).	----------	Inactivated.

(----) Not tested.

It can be seen that 10–12° F. stands between pasteurization temperatures in a given period and possible survival of either one or both hepatitis viruses. Although the data apply for the most part to virus B, its similarity to virus A could mean that pasteurization by the holding method might have little effect on hepatitis A virus.

The possibility of fomite transmission was explored. Dairy 2 operated four routes, using two drivers handling two routes each. On Sat-

Table 2. Bacteriological reports on raw milk from dairy 2 and its other producers on 2 collection dates

Producer and daily production	Standard plate count per milliliter		Laboratory pasteurized plate count per milliliter	
	Jan. 20, 1964	Feb. 14, 1964	Jan. 20, 1964	Feb. 14, 1964
Producer 1—200 qts	48, 000	<30, 000	570	300
Producer 2—400 qts	190, 000	31, 000	>6, 500	4, 100
Producer 3—60 qts [1]	<30, 000	<30, 000	<300	<300
Dairy 2—400 qts	99, 000	35, 000	400	300

[1] Production discontinued.

urdays, two teenage boys assisted in house-to-house deliveries. Cases of hepatitis were nearly evenly divided among the two drivers' routes. As noted, all personnel at dairy 2 had up-to-date annual health certificates. They also had no history of "jaundice." The two boys employed on Saturdays as delivery helpers were also without incriminating history, either personal or familial. In addition, the plastic caps of the milk bottles protected their pouring edges from manual and other kinds of contamination.

The cases that were compatible with a dairy 2 origin totaled 17. One of these (table 1, case 31) occurred in an 18-year-old woman who purchased milk indiscriminately from a local store handling several brands, including milk from dairy 2.

Water supply. No evidence revealed that any water supply was involved in the epidemic until case 13 occurred on December 16, 1963, in a 33-year-old man (a member of family H and resident of area B). A week later infectious hepatitis was reported and confirmed in the man's wife (case 15). Cases 21 and 22 were noted from area B on January 24 and 25, 1964, respectively. These two cases involved a 38-year-old woman and a 20-year-old man of family M. A State test of the well that supplied both families indicated that the water was polluted and unfit for home use. The husband and wife of family H continued to use the water after the test results were known, while the M family used the water only for purposes other than drinking, buying bottled water to drink "because the well water smelled bad." The contractor who had built the housing for this immediate area had blasted a rocky substratum to increase percolation into the well. The well was situated at the low point in the valley, downgrade from numerous septic tanks and was separated from the cesspool of family D (cases 4–9) by a rocky ridge and 700 yards of shallow, ledge-punctured soil. Case 26 occurred in a 7-year-old girl from family R of area B. Her family used a well for water supply similar to that used by families H and M. This child had many known contacts with children at school who had infectious cases. ("Many kids at school are sick," she reported.) Therefore her disease was deemed to be the result of person-to-person transmission. The husband and wife of family H (cases 13 and 15) did not reveal definite infective contacts, but the two members of family M (cases 21 and 22) had often visited their neighbors (cases 13 and 16). Several other families in the area used similar wells, but did not report illness compatible with hepatitis. One can only speculate on the possible role of

Table 3. Bacteriological reports on samples of pasteurized milk and cream at dairy 2

Sample	Date of collection	Standard plate count per milliliter at 35° C.	Coliform colonies per milliliter
Homogenized milk.	Feb. 14, 1964	<3, 000	[1] 6
Do	do	18, 000	1
Do	Mar. 2, 1964	9, 600	[1 2] >300
Do	Apr. 6, 1964	10, 000	<1
Do	do	9, 300	<1
Do	do	<3, 000	[1] 94
Do	do	3, 600	5
Milk (nonhomogenized).	Feb. 14, 1964	<3, 000	1
Do	Mar. 2, 1964	10, 000	[1 2] 11
Do	Apr. 6, 1964	<3, 000	1
Do	do	3, 500	1
Light cream	Feb. 14, 1964	[1] 55, 000	>300
Heavy cream	Mar. 2, 1964	<3, 000	[2] 34
Do	Apr. 6, 1964	[1] 150, 000	23
Light cream	do	[1] 300, 000	8

[1] Notation made on laboratory reports that count failed to meet legal requirements (7 of 15 samples, or 46.7 percent).
[2] Samples taken from local grocery store.

the family D dog in fomite transmission of the virus during his frequent visits to neighborhood homes. Several persons in these homes developed cases after the onset of the cases in family D—the persons with cases 13 and 15 in family H, for example.

Group exposure. Exposure through sizable gatherings other than routine school assemblage was not found to have been influential in this disease outbreak except in the Halloween episode involving family D. The largest single factor in propagation of the epidemic was apparently school and family or playtime contacts. At least 21 of 32 cases could be called school-associated. If the parents and contacts of school-age children are taken into account, only five cases appear not to have been school associated, namely, cases 1, 13, 15, 21, and 22. Ten of the 20 cases of infectious hepatitis reported in school children affected pupils from school H, where inadequate water pressure probably contributed to the difficulties of achieving proper personal hygiene.

Summary

An outbreak of infectious hepatitis in a village complex of 9,600 people reached a total of 32 reported and 2 symptomatic unreported cases over an 11-month period. An epidemiologic investigation was undertaken to ascertain the sources of infection. Personal contacts, milk, water, and raw shellfish were under suspicion.

About 65 percent of the reported cases were in persons 15 years old or younger. If cases in parents and contacts of school-age children are counted as school-associated, all but 5 of the 32 reported cases would be placed in this category. Ten of the 20 school-age children with confirmed cases attended a school in which inadequate water pressure presented problems in personal hygiene. Crowded and insanitary conditions prevailed in several of the children's homes.

In no case was sufficient evidence revealed to indicate that the disease had been transmitted by any other means than personal contact.

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