HEPATITIS A ASSOCIATED WITH A HARDWARE STORE WATER FOUNTAIN AND A CONTAMINATED WELL IN LANCASTER COUNTY, PENNSYLVANIA, 1980

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In August–October 1980, a sudden increase occurred in the number of cases of jaundice reported among residents of a rural, agricultural section of Lancaster County, Pennsylvania. Investigation confirmed the cases as hepatitis A and showed that the outbreak was associated with consumption of water from a water fountain in a hardware store and water from the adjacent family home, both of which came from a well contaminated with feces. A total of 49 cases occurred from August 11 to October 21 in store customers, employees, family members, and persons visiting the family residence. Unusual features of the outbreak included an epidemic curve with two peaks, a very high attack rate in susceptibles at highest risk (>90%), a high proportion of cases with jaundice (85%), absence of asymptomatic cases, and a high male to female ratio due to the makeup of the group at risk.

antibodies; hepatitis; hepatitis A; jaundice; water pollution

Common-source outbreaks of hepatitis A have been frequently reported in the past. Milk, water, food, specific individuals, institutions, and day-care centers have been identified as sources. City water supplies (1), wells, surface water contamination of local water systems (2), orange juice (3), and Mai Tai (4) have been identified as specific common sources of waterborne outbreaks. Most previous reports have relied on clinical and biochemical data to establish the diagnosis of viral hepatitis, infectious hepatitis, or hepatitis A.

On September 24, 1980, one of us (MAM), while reviewing surveillance data, noticed an increase in the number of infectious hepatitis case report forms from Lancaster County, Pennsylvania, being received at the Pennsylvania Department of Health in Harrisburg. The usual number was one or less per week. A telephone call to the supervisory public health nurse of the local office of the Pennsylvania Department of Health in Lancaster, which is responsible for Lancaster County, revealed 13 cases. Six of the early cases were in employees of a single hardware store in northern Lancaster County. An epidemiologic investigation was begun and the data generated are the basis of this report.
Materials and methods

Documentation of hepatitis A or infectious hepatitis cases in Lancaster County from November 1979 to October 1980 was done by reviewing case reports on file in Harrisburg and at the Lancaster office of the Pennsylvania Department of Health; by reviewing medical records and discharge diagnosis, emergency room, and chemistry laboratory records at Ephrata Hospital, Lancaster County; by telephoning a sample of area primary-care physicians and sending others a letter requesting rapid reporting of cases; by contacting infection control nurses and infectious disease physicians at area hospitals; and by asking ill persons for names of other similarly ill persons.

Initially, all patients were interviewed by telephone or in person to obtain clinical data, to discover previously unknown cases, and to obtain information about social gatherings, travel, employment, food consumption, sources of food and water, medications, and drug usage. A total of 38 patients or adults in patients' families were interviewed 4—5 weeks after onset of illness to detect secondary cases in households of primary cases. We found 178 persons to be household contacts of the cases. Questioning was directed toward discovery of milder, non-icteric cases of hepatitis.

Initial interviews with all cases showed the hardware store and adjacent family home to be the source of this outbreak (see Results). Once this was established, we investigated the source and mode of transmission of the outbreak by contacting groups of people who had visited the hardware store premises in August and September, 1980. These groups included hardware store employees, family members of the owner of the store, members of a youth choir which met every other week at the home of the owner of the store, a group of girl choir members who attended a slumber party at the family home, and hardware store customers. A list of credit customers was obtained from the owner of the hardware store and every fourth person on the list was interviewed if they could be reached by repeated telephone calls. No list of cash customers was available.

Blood specimens were collected from ill and well store employees, family members, youth choir members, and 67 percent of known cases 4—8 weeks after onset of illness. Blood specimens were tested for presence of hepatitis A-specific IgG and IgM antibody by the Hepatitis Laboratories Division, Centers for Disease Control, Phoenix, AZ, using commercially available radioimmunoassay kits (5) (Abbott Laboratories, N. Chicago, IL).

Environmental investigation

On September 9, 1980, personnel of the Department of Environmental Resources, Pennsylvania Department of Health, examined the well which supplied the hardware store and family home, took water samples from the water fountain, and surveyed the septic and drain field systems of the store and family home. On September 22, water samples were taken from the well before the well water entered the pressure tank. Samples were also taken on September 22 from two wells located on adjacent properties. Water specimens from the wells and water fountain were cultured for fecal coliforms by the Bureau of Laboratories, Department of Environmental Resources, Harrisburg, PA.

On November 5, 1980, a dye test was conducted by the Department of Environmental Resources of the sewage disposal system at the hardware store to see if sewage from the store toilet could contaminate the well. The procedure used was the standard State of Pennsylvania testing procedure. Four tablespoons of uranine dye were flushed down the toilet in the hardware store. One week later, well water at the store was sampled and tested for presence of dye.
In order to understand soil and rock conditions and possible surface and subsurface water movements within the area, a geologic report was obtained from the Environmental Geology Division, Bureau of Topographic and Geologic Survey, Department of Natural Resources, State of Pennsylvania.

**Case definition**

A case was defined as a person with either jaundice in the absence of gall bladder disease or previous blood transfusion plus elevation in bilirubin and one of the serum transaminases, or clinical illness consisting of any four of the following signs or symptoms: weakness, lethargy or fatigue, anorexia, nausea or vomiting, abdominal pain, or dark urine, or an ill person with less than four of the above symptoms who had hepatitis A virus IgM antibody (HAV IgM Ab).

**RESULTS**

**Outbreak investigation**

**Endemic cases.** From November 1979 to August 1980, 30 cases meeting our case definition had been reported from Lancaster County to the Pennsylvania State Health Department, for a biweekly rate of 0–3. As shown in figure 1, there was a

![Graph showing hepatitis A cases in Lancaster County, Pennsylvania, from November 1979 to October 1980. Clear boxes or histograms are cases associated with the epidemic at the hardware store. Stippled boxes are cases that occurred during the year which were not associated with the hardware store and represent the background or endemic level of transmission in the county.](https://academic.oup.com/aje/article-abstract/117/6/695/125850/HEPATITIS-A-ASSOCIATED-WITH-A-HARDWARE-STORE-WATER/697)
small peak in this background or "endemic" level of transmission between June 15 and July 15, 1980. This peak was not investigated for source. Greater than 95 per cent of the cases reported before August 1980 were in Amish persons in the area of the county north and east of Lancaster city. There was a slight preponderance of male endemic cases (male to female ratio 1.3:1) and 40 per cent of the endemic cases were <16 years of age (table 1). The population of the county is about 360,000; the crude annual attack rate for the county was 8.3/100,000. The population of the townships in which the cases occurred was 72,000 by the 1970 US Census. The attack rate for these townships was 41.7/100,000.

**Epidemic cases.** In September 1980, the large increase in reported hepatitis A cases prompted the current investigation, and we identified 55 cases which met our case definition between August 1 and October 31, 1980. Forty-nine cases in Lancaster County were epidemiologically associated with the hardware store or the adjacent family home. Five cases in nearby southern Lebanon County attended a common social gathering, but were not associated with the hardware store. One case was unrelated to either of these outbreaks.

The epidemic curve for this outbreak is shown in figure 2. The index case became ill on August 11 and the last case became ill on October 16. The outbreak had an early peak between September 4 and September 6 and a later peak from September 13—September 24.

Over 90 per cent of the cases lived in Lititz, Ephrata, or on farms in the rural area within a 5 mi (8.1 km) radius of a hardware store located 3 mi (4.8 km) southwest of Lititz, Clay Township, Lancaster County. Six cases actually lived in Ephrata while seven lived in Lititz. Both towns have municipal water supplies. The farms were served by wells.

The age and sex distribution of the epidemic cases is shown in the right hand side of table 1. The male-to-female sex ratio of the cases was 6:1. Forty of the 49 cases (82 per cent) were between 16 and 50 years of age. Only seven of the epidemic cases (14 per cent) were in persons <15 years of age. This was an unusual age distribution for hepatitis A in Lancaster County; as shown in table 1, 40 per cent of the background or endemic

### Table 1

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Endemic cases*</th>
<th>Epidemic cases†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>0–5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6–10</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>11–15</td>
<td>6</td>
<td>1</td>
</tr>
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<td>16–20</td>
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<td>21–25</td>
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<td>26–30</td>
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<td>31–40</td>
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<td>3</td>
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<td>41–50</td>
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<td>0</td>
</tr>
<tr>
<td>51+</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>13</td>
</tr>
</tbody>
</table>

* Endemic cases include all hepatitis A cases reported from Lancaster County for one year between November, 1979 and October, 1980 which were not associated with the epidemic at the hardware store. These cases represent the background level of transmission.

† Epidemic cases include only those cases associated with the hardware store from August–October, 1980.
cases were less than 16 years of age. The attack rate for the eight townships in which cases occurred was 106.6/100,000.

**Occupations.** The occupations of the 49 cases are shown in table 2. Twelve (24.5 per cent) were full-time or part-time employees of the hardware store, which sold supplies and had an attached welding shop where equipment including farm equipment was repaired. Nine cases were farmers or agricultural workers who traded at the hardware store; six were employed in construction; all did business with and had visited the hardware store. Three people were mechanics or repaired engines or power equipment and all three had visited the hardware store. Three cases were family members of the owner of the hardware store and lived in the adjacent home. One case was a family friend who frequently visited the house. Four people had other occupations (see table 2) which brought them in person to trade at the hardware store. Five cases were students who had visited the home or hardware store.

Six people were members of a youth choir, which met every other week at the home of the owner of the hardware store. Four of these cases did not visit the hardware store on other business. Three cases were members of the choir and also were among a group of 11 females who attended a slumber party at the home of the hardware store owner on August 23. The choir met at the family home on August 6 and 20 and September 3.

**Table 2**

*Occupations of hepatitis A cases, Lancaster County, Pennsylvania, August—October, 1980*

<table>
<thead>
<tr>
<th>Occupation</th>
<th>No. of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware store employee</td>
<td>11</td>
</tr>
<tr>
<td>Farmer/agriculture</td>
<td>9</td>
</tr>
<tr>
<td>Part-time employee of hardware store</td>
<td>1</td>
</tr>
<tr>
<td>Construction (carpenter, cabinetmaker, roofer, etc.)</td>
<td>6</td>
</tr>
<tr>
<td>Mechanic (engine repair/power equipment repair)</td>
<td>3</td>
</tr>
<tr>
<td>Family of hardware store owner</td>
<td>3</td>
</tr>
<tr>
<td>Youth choir member</td>
<td>6</td>
</tr>
<tr>
<td>Crop sprayer</td>
<td>1</td>
</tr>
<tr>
<td>Housewife (friend of family of owner of hardware store)</td>
<td>1</td>
</tr>
<tr>
<td>Feed mill worker</td>
<td>1</td>
</tr>
<tr>
<td>Egg processing</td>
<td>1</td>
</tr>
<tr>
<td>Truck driver</td>
<td>1</td>
</tr>
<tr>
<td>Student</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49</strong></td>
</tr>
</tbody>
</table>
The index case was a 29-year-old male employee of the hardware store. The other two August cases and five of the seven cases in the first September peak were hardware store employees (figure 2). There was one late case in a store employee whose date of onset was October 5. This person was out of town during August and did not return to work until September 5. The second peak which occurred between September 14 and 25 was made up principally of hardware store customers, but also included members of the youth choir.

**Investigation into other possible sources.** We carefully searched for other sources for this outbreak; the 49 cases had only one thing in common—visiting or working at the hardware store or visiting the family home next door in August or September. The ill people did not share the same municipal water supply. The majority lived on farms with wells, while 13 cases were split equally between Lititz and Ephrata, which had separate water systems. They did not attend a common social group, church, or other organization. They had not travelled together. They did not buy food at the same grocery store, bakery, or dairy. They did not use the same medications or drugs. They did not eat at a common restaurant, fast food establishment, or bakery. With the exception of working at the hardware store, the cases did not work at the same place. Thus, the hardware store and adjacent home were strongly implicated as the source of the outbreak.

**Investigation into the mode of transmission.** Once it had been established that the hardware store and adjoining home were undoubtedly the source of the outbreak, the mode of transmission was investigated. No food or drinks were served at the hardware store. There were no vending machines of any kind. The employees brought lunch from home in bags or went home for lunch. They did not share food, cigarettes, or drinks. The employees did not have intimate personal or social contact with each other or with store customers, making person-to-person transmission unlikely. The hardware store and family home, but no other homes, were supplied by a common well. The hardware store contained a water fountain, which was used by employees and customers alike. A well, located in the basement of the hardware store, supplied the water fountain and the water for the family home. There was a toilet facility in the office of the store, which was used by all store employees including the index case, but not the store customers.

Two cases each occurred in only four families. They occurred 3–8 days apart. This made person-to-person transmission unlikely. There were also clusters of cases in store employees between September 1 and 6, in choir members between September 15 and 24, and in customers who had no intimate social contact with each other or with store employees between September 13 and 24 (see figure 2). These clusters were most likely common source clusters, not person-to-person transmitted chains of transmission.

We obtained water consumption histories from 44 store customers and 26 youth choir members. Seven of eight store customers who drank water from the water fountain became ill. Two of the 36 customers who stated they did not drink water at the store were ill. Drinking water was highly associated with illness ($p < 0.001$ by Fisher's exact test). A similar association between illness and drinking water was shown among the choir members. Twenty-six persons attended both the August 6 and August 20 choir meetings; six out of 10 persons who drank the water became ill versus none out of 16 persons who did not drink the water ($p < 0.001$). Thus, drinking water at the store or home was highly associated with illness.

Further evidence that water was the mode of transmission in this outbreak is
presented in table 3, which shows a "dose-response" relationship between degree of exposure to the water at the store or family home and illness. The attack rates for the various groups of people at risk during the outbreak decline as the length and frequency of contact with water at the store-home premises decreases. Persons shown to be immune by serological testing (IgG but no IgM antibody present in serum 4–8 weeks after onset of illness) were excluded from the denominators of at risk store employees, family members, youth choir members, and attendees of the pajama party. The attack rate was 100 per cent for susceptible family members who day and night throughout the outbreak drank water from the well. The attack rate was 92 per cent for susceptible store employees who had daily exposure to the water, 27 per cent for girls who attended the overnight pajama party at the family home in addition to attending youth choir practice at the home, and 9.6 per cent for other youth choir members. A true attack rate could not be obtained for store customers because a complete listing of customers was not available, but a conservative estimate is that 1000 to 1500 customers were at risk. Since there were 29 cases in store customers, an estimated attack rate for all customers would be 1.9 to 2.9 per cent.

Serology. Blood specimens were obtained from 32 clinical cases (two-thirds of the cases) and 36 well persons in the youth choir. All clinically ill persons had IgM antibody to hepatitis A. Family members, store employees, and youth choir members were bled, including those not ill. No asymptomatic recent infections were discovered among the youth choir, employees, or family members. Three of the 36 well youth choir members had IgG but no IgM antibody, indicating that they had previously been infected. The antibody prevalence for this age group was 8 per cent.

Environmental investigation

The water supply for the hardware store and family home was a 200 ft (61 m)
well drilled through the Beekmantown group of the carbonate rocks dolomite and limestone. The water table level was 175 ft (53 m). The rock is fractured and soluble in groundwater. Rain with any surface contaminants moves through the soil and easily through the rock along fracture lines down gravity gradients to lower elevations.

Water is transferred from the well to an 80 gall (303 liter) pressure tank by means of a pump. Water passes from the pressure tank to the drinking fountain through a cartridge carbon filter. Two samples of water were taken from the drinking fountain on September 9, 1980. Both contained total coliforms of >200/100 ml and fecal coliforms of >60/100 ml. On September 22, two water samples from the pressure tank of the well contained >200 fecal coliforms/100 ml. Water taken September 22 from wells located on two adjacent properties were negative for fecal coliforms.

There was an employee toilet facility located adjacent to the office of the hardware store. The septic tank and drain field for the store toilet are located on flat ground behind the store to the north (see figure 3). The family home was located 300 ft (91 m) to the east of the hardware store, and the septic tank and drain field for the house toilet were behind the house to the north. On November 5, four tablespoons of uranine dye were flushed down the toilet in the hardware store. On November 12, the well and water line leading to the water fountain were sampled; no dye was measurable.

**Control of the outbreak**

On September 12, a bottled water system was substituted for well water at the store and family home. Immune serum globulin was administered to family members of cases. No cases were recognized after October 16. This time (five weeks) corresponds to one incubation period of hepatitis A.

Telephone interviews were conducted with 39 cases four to six weeks after onset of illness. These cases had 179 household contacts. No cases of jaundice were discovered. Likewise, no one with symptoms compatible with anicteric hepatitis such as fatigue, low grade fever, anorexia, weight loss, tea colored urine, etc., was found. One person with gastrointestinal

![Figure 3. Schematic diagram of location of well, septic tanks, and drain fields associated with hepatitis A outbreak, Lancaster County, Pennsylvania, August to October, 1980. (1 foot = 0.3 m.)](https://academic.oup.com/aje/article-abstract/117/6/695/125850/HEPATITIS-A-ASSOCIATED-WITH-A-HARDWARE-STORE-WATER/1810)
symptoms only was found. Thus, the secondary attack rate and rate of anicteric hepatitis appeared to be low.

**DISCUSSION**

This outbreak is unusual in that it is a common source drinking water-associated outbreak with a prolonged intermittent or continuous period of well and drinking water contamination. Five groups of people "at risk" because of exposure to the contaminated water had attack rates which showed a "dose-response" relationship between attack rate and length and degree of exposure. The outbreak was also unusual because the attack rate for persons with highest exposure to the water was quite high (92–100 per cent) compared to other common source outbreaks (e.g., 3, 4). It was also unusual that no asymptomatic cases were found among the groups of persons from whom blood was collected (employees, family, youth choir); the proportion of jaundiced cases was very high; and the clinical secondary attack rate was low. The unusual male to female sex ratio among the cases was due to the fact that the persons doing business with or employed by the hardware store were mostly males.

Most of the cases in this outbreak were documented serologically. Both IgG and IgM antibody were measured for two-thirds of the cases and additional persons potentially exposed to contaminated water but not clinically ill. These tests were extremely useful to show that five persons at risk were really already immune and that no asymptomatic infections occurred. We believe that the usefulness of serologic testing during hepatitis A outbreak investigations has been clearly established, and we strongly recommend that these tests be carried out as part of future investigations.

It seems clear that the drinking water rather than food, beverage, common gathering or person-to-person spread was the mode of transmission. No convincing evidence for the other modes of transmission could be obtained, although the possibility that there could have been other modes was carefully examined. All the cases had contact with the hardware store or family home, but had nothing else in common. Convincing evidence for water as the source came from interviewing the patients and controls among store customers and youth choir members; drinking water at the home or store was highly associated with illness. In addition, a dose-response relationship between degree of exposure to the water and attack rate was demonstrated for the five groups of people at risk at the store and home. The well and water fountain were shown to be contaminated by fecal coliforms. Lastly, the outbreak ceased one incubation period after bottled water was substituted for well water at the store and home.

The route of contamination of the well that supplied the family home and the store water fountain was not satisfactorily demonstrated. Because of the proximity of the well to the store toilet and the septic systems for the house and store, this route is highly suspect. The dye test performed after the outbreak did not show this route of contamination to be present at the time the test was performed. Alternatively, another surface water source could have been responsible, although other nearby wells were not affected.

If the store toilet were the source of the well contamination for most of the cases, then the period of possible well contamination was about 40 days, from about August 4 to September 12, when the bottled water was substituted. This is so because the index case who used the store toilet became ill on August 11. If he excreted virus from one week before onset of illness (6), he began shedding virus into the toilet facility and, perhaps, the well on August 4. Other employees using the toilet before their illnesses could also have contributed virus to contaminate the
well. Virus had to have been present as late as September 5, when the last ill store employee returned to work after a month's absence. Fecal contamination of the well was demonstrated on September 9 and 22. One male choir member whose illness began on September 16 attended choir practice at the home on August 6 and 20 and September 3, but did not visit the store or home at any other time. His exposure was probably on August 20. The three ill females who attended the pajama party on August 23 and the three choir practices became ill September 17, 19, and 24. They were probably exposed on August 20 or 23. Other male choir members visited the store or home on other, unspecified, dates and may have been exposed at any one of the visits.

It is not clear whether virus was present continuously or intermittently in the well water. The shape of the epidemic curve with several peaks implies that, perhaps, more virus was present in the water at some times than others or that contamination may have been intermittent.

The maximum attack rate in this outbreak for employees and family members who had earliest and most prolonged exposure to the water was 93 per cent. The attack rate for these maximally exposed people is high compared to other hepatitis A common source outbreaks reported in the literature. In most outbreaks, attack rates have ranged from 7–8 per cent to 64 per cent (3, 4, 7–9). Attack rates have been reported to be as high as 67–83 per cent in residents of institutions and in chimpanzee associated outbreaks (10–12). The Holy Cross football team outbreak (2) had an attack rate of >90 per cent, but many cases were asymptomatic.

The absence of asymptomatic cases in the relatively highly exposed youth choir group and in the attendees of the pajama party was unexpected, as was the relatively high proportion of jaundiced patients (85 per cent). No evidence for clinically compatible anicteric illness in exposed groups or families of cases was obtained. Osterholm et al. (8) did report a 4:1 clinical to subclinical case ratio during a foodborne outbreak, but equal numbers of asymptomatic and symptomatic cases were reported by Rakela et al. (10). In the Holy Cross outbreak (2), 40 per cent of infections were asymptomatic in a comparable age group. Recent studies by Storch et al. (13) and Halder et al. (14) indicate that young children are more likely to have asymptomatic infections than adults. In these studies, symptomatic adults were day-care center employees, parents, or adult household contacts of young children who attended day-care centers. Perhaps gross contamination of the well water with feces or water containing virus in the Lancaster County outbreak resulted in clinical cases in those exposed and no low dose exposures leading to asymptomatic infection.

Waterborne hepatitis A outbreaks have been reported many times in the past. In 1966, Taylor et al. (15) analyzed the data of 48 domestic and foreign outbreaks of hepatitis; 17 of these outbreaks were associated with wells, resulting in 1146 cases (average, 67 cases/outbreak). The Lancaster County outbreak, with 49 cases, is therefore slightly smaller than the average for well-associated waterborne outbreaks (15). The large waterborne outbreaks which have involved hundreds or thousands of cases have been associated with contaminated municipal water supplies.

During this investigation, more than half of the cases were discovered as a result of asking known patients if they knew of other persons who were ill with the same syndrome. This method of finding ill people should not be overlooked during the epidemiologic investigation of any outbreak, especially in rural areas and small towns or among particular social, religious, or ethnic groups in which the members know each other well.
REFERENCES


