

Community Health Effects of a Municipal Water Supply Hyperfluoridation Accident

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Abstract: For 12 hours, excess hydrofluorosilicic acid was diverted to a 127-home community water supply. Fluoride levels peaked at 51 parts per million (ppm). Water acidification caused copper to leach from the domestic plumbing; raising copper levels to 25–41 ppm. Fifty-two (33 per cent) of those who drank hyperfluoridated water developed mild gastroenteritis. Vomiting was uncommon and symptom onsets usually occurred >30 minutes after drinking water; suggesting that fluoride, rather than copper, caused illness. Skin contact with hyperfluoridated water caused itching and skin rashes. (*Am J Public Health* 1988; 78:711–713.)

Introduction

Hyperfluoridation accidents in public water supplies are uncommon^{1–3} and accidents in municipal water supplies have been reported only twice previously.^{4,5} This report describes the public health effects of a third municipal water supply hyperfluoridation accident that occurred in a residential Connecticut community.

Background

The community has 127 homes. Its water source is a nearby treatment plant which also supplies water to three distant larger metropolitan areas. The community is on a "dead-end" portion of the water distribution system. The street water mains are cement lined while feeder lines from the street to each house are copper as is the piping within the houses.

At the treatment plant, hydrofluorosilicic acid (H_2SiF_6) is injected into the water supply. At approximately 3:00 pm on March 11, 1986, an inadvertently opened valve began to divert hydrofluorosilicic acid that normally would have been injected into water supplying the community and distant metropolitan areas, solely into the community's water supply. Hyperfluoridated water would have reached the domestic taps at approximately 6:00 pm (beginning of exposure period, time = 0 hours). At +1 hours (7:00 pm) residents began notifying water company personnel that the water tasted abnormal and turned blue on contact with soap, and of itching and gastrointestinal symptoms. At +1 and +4 hours (7:00 and 10:00 pm), household tap water samples revealed fluoride and copper concentrations >40 times normal (fluoride 42–51 ppm [normal 1.0 ppm], copper 25–41 ppm [normal 0.03 ppm]).

At +10 hours (4:00 am), a sample of water from a water main had fluoride and copper concentrations of 50 ppm and 0.03 ppm, respectively. The water mains were then flushed. Beginning at +12 hours (6:00 am), residents were told not to

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drink or bathe in the water and to discard ice or beverages made with tap water.

Methods

Epidemiologic Investigation

On March 15, 1986, a door-to-door survey of the 127 community households was conducted. Data were obtained from at least one adult (>16 years in age) to determine each household member's water consumption, dermal exposure to water, and symptoms.

The exposure period was considered to have been +0 hours to +12 hours. The quantity of ingested hyperfluoridated water was estimated as the number of glasses of tap water consumed during the exposure period plus the number of glasses of beverages made from tap water during that period. The latent interval was defined as the time from consumption of the last glass of hyperfluoridated water to the illness onset. A person was considered dermally exposed to the hyperfluoridated water if that person bathed or showered at home during the exposure period.

The outbreak period was defined from 0 to +54 hours. A case of gastrointestinal irritation was a resident with onset during this period of any of the following symptoms: diarrhea (≥ 2 watery stools in a 24-hr period), abdominal cramping, severe nausea, or vomiting. A case of skin irritation was a resident with onset of unusual itching during the outbreak period.

Statistical relations between water consumption or dermal exposure and illness were determined by the method of related ratios to control for household.^{6,7} The dose-response relation of water consumption and gastroenteritis was assessed by the Mantel Chi square test for trend⁸; other differences were assessed by the Chi square test. The effective dose of hyperfluoridated water that would be expected to cause gastroenteritis in 50 per cent of a population (ED_{50}) was calculated by the log probit method.⁹

Results

Information concerning 321 persons was gathered from 86 (68 per cent) of the 127 households. Representatives from two households refused interviews and in 39 households no adult was available for interview on the survey day. Abnormal taste or color of water was reported in 62 per cent (53/86) of households.

Gastrointestinal Illness

Gastrointestinal symptom histories were obtained for 312 persons, 55 (18 per cent) of whom were cases; symptoms included: abdominal cramping (66 per cent), nausea (62 per cent), headache (49 per cent), diarrhea (42 per cent), vomiting (13 per cent), diaphoresis (12 per cent), and fever (4 per cent). The onset of illness for the 46 persons with known time of symptom onset is depicted in Figure 1. The median duration of gastroenteritis symptoms was 5.5 hours with a range of 1 to 60 hours. No person sought medical evaluation for gastroenteritis symptoms.

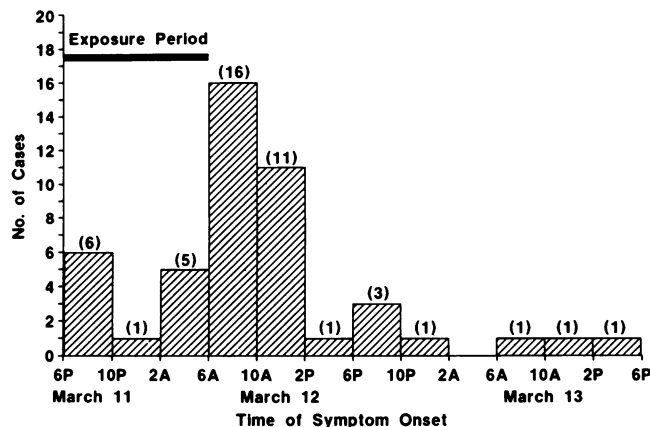


FIGURE 1—Gastroenteritis, by Time of Symptom Onset, Connecticut Community, March 11–13, 1986

Water consumption and symptom histories were available for 301 persons. Of the 160 persons who drank water, 52 (33 per cent) had gastroenteritis compared to only two (1.4 per cent) of the 141 persons who did not drink water (relative risk = 23; 95 per cent confidence intervals = 5.7, 92.4). Information about latent interval was available for 37 persons and, for those persons, the median latent interval was two hours (Figure 2). Only four persons (11 per cent) had symptom onsets <30 minutes after drinking water. Attack rates were similar by gender, age, and location of residence.

Attack rates by quantity of tap water consumed for 160 persons for whom data were available were: 29 per cent (33/114), 1–2 glasses; 31 per cent (11/36), 3–4 glasses; and 80 per cent (8/10), ≥5 glasses. The calculated ED₅₀ was 2.7 glasses of water (95 per cent CI = 1.8, 4.1). This corresponded to 33.8 mg of fluoride and 20.2 mg of copper if an average glass of water was 250 cc and contained 50 ppm of fluoride and 30 ppm of copper.

Skin Irritation

Of the 300 persons whose skin irritation histories were obtained, 30 (10 per cent) reported unusual itching, with a duration of 2 to 62 hours. Of these 30 persons, 12 reported skin rash compared to only two of 270 persons who did not report itching. No person had a skin rash on the survey day.

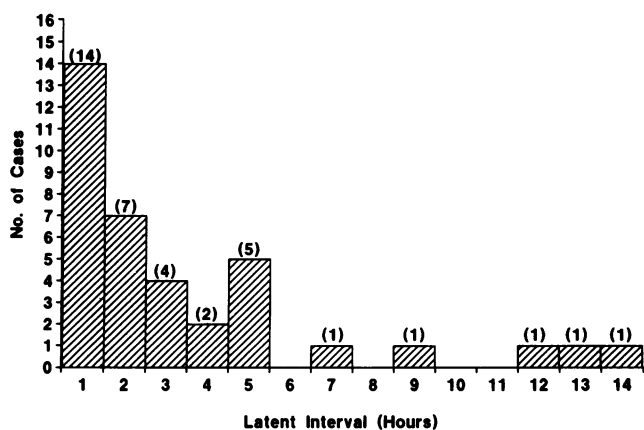


FIGURE 2—Interval from Water Consumption to Onset of Gastroenteritis, Connecticut Community, March 11–13, 1986

TABLE 1—Cases of Skin Irritation by Bathing or Showering Status, Connecticut Community, March 11–12, 1986

Water Exposure	Cases	Total*	Attack Rate %	Rate Ratio	95% Confidence Intervals
Bath	5	19	26	4.2	1.7–10.7
Shower	13	88	15	2.4	1.1–5.0
Neither	11	176	6	1.0	
Unknown	1	17			
Totals	30	300			

*21 persons had unknown skin irritation histories.

Persons dermally exposed to hyperfluoridated water in a shower or bath (Table 1) were 2.7 times as likely to have reported itching than unexposed persons (95 per cent CI = 4, 5.3). Persons who reported itching, but who had not bathed or showered, had other water exposures such as dishwashing, and their itching was localized to the area of water contact.

Discussion

This hyperfluoridation accident was caused by diversion of excess hydrofluorosilicic acid into a community water supply. The resultant water acidification substantially elevated water copper levels by solubilizing copper compounds coating the domestic copper service lines, as demonstrated by elevated copper levels in tap water and normal levels in water main water. In the previous municipal water supply outbreak caused by excess hydrofluorosilicic acid, high iron levels resulted from contact with iron pipes.⁴

Although one-third of those who drank the water became ill, symptoms were mild and of short duration. The ED₅₀ of 2.7 glasses of water in this outbreak corresponded to symptom-producing doses of copper and fluoride observed in other studies. Copper ingestion causes vomiting usually within 10 minutes,¹⁰ and outbreaks have occurred in water supplies containing from 4–430 ppm of copper^{10–13} and with as little as a 5 mg ingested dose.¹⁰

Low-dose fluoride ingestion causes nausea, vomiting, abdominal cramping, and diarrhea,^{1,2,4,14} and outbreaks have occurred in water supplies with levels from 30 to >1,000 ppm.^{1–5} Symptoms occur with a 5 mg ingested dose.¹⁵ Both copper and fluoride may have had additive effects in this outbreak; however, the infrequency of vomiting and symptoms occurrences <30 minutes after water ingestion suggested fluoride toxicity.

Skin irritation symptoms with a hyperfluoridation accident have not been reported and, in this outbreak, could have been caused by fluoride, copper, or the water's acidity. Although hydrofluorosilicic acid produces burns in high concentrations,¹⁶ its cutaneous effects in low concentrations are unknown. Dermal applied copper salts can produce itching and skin rash¹⁷ but the cutaneous effects of copper at levels recorded in this outbreak are unclear.

ACKNOWLEDGMENTS

The authors thank Loraine Good for editorial assistance with manuscript preparation and Dr. Robert Gunn for his advice during all phases of the investigation.

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Institute of Medicine Invites Nominations for Lienhard Award

The Institute of Medicine is accepting nominations for the third annual Gustav O. Lienhard Award. The award, consisting of a medal and \$25,000, recognizes individuals for outstanding achievement in improving personal health care services in the United States.

Support for the award is provided by the Robert Wood Johnson Foundation. Mr. Lienhard was chairman of the Foundation's board of trustees from 1971 to 1986, a period in which the Foundation moved to the forefront of American philanthropy in health care.

The emphasis of the Gustav O. Lienhard Award is on creative or pioneering efforts that have appreciably improved personal health services rather than on the science base of health care. To encourage consideration of the widest possible range of candidates, there are no eligibility limits with respect to the education and profession of individuals that may be nominated. Any individual or group may submit a nomination.

The award is presented by the Institute of Medicine at its October annual meeting in Washington, DC, where ceremonies afford opportunity both for honoring the recipients and for disseminating information about their accomplishments. The first recipient was Julius B. Richmond, leader of federal programs for Head Start and Neighborhood Health Centers in 1960s and 1970s; the second was Ernest W. Seward, a pioneer in the establishment of prepaid group health plans.

A panel of experts in various aspects of health care, convened by the Institute of Medicine, will receive, consider, and make recommendations on nominations for the award. The panel's recommendations will be acted on by the Institute's governing council and president.

Names of nominees should be accompanied by a detailed written description of their accomplishments meriting this award. Only written material will be considered. Nominations must be postmarked by June 24, 1988, and should be submitted to: Ms. Kay C. Harris, The Lienhard Award Committee, Institute of Medicine, Room 213, 2101 Constitution Avenue, NW, Washington, DC 20418.