Health Consultation

ROSEMOUNT WOODS MERCURY INCIDENT

CITY OF ROSEMOUNT, DAKOTA COUNTY, MINNESOTA

JULY 13, 2005

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

HEALTH CONSULTATION

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Prepared by:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment of Consultation

FOREWORD

This document summarizes health concerns associated with a mercury spill in a manufactured home park. This document is based on a formal site evaluation prepared by the Minnesota Department of Health (MDH). A number of steps are necessary to do such an evaluation, and include the following:

- Evaluating exposure: MDH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is found on the site, and how people might be exposed to it. Usually, MDH does not collect environmental sampling data. We rely on information provided by the Minnesota Pollution Control Agency (MPCA), U.S. Environmental Protection Agency (EPA), and other government agencies, businesses, and the general public.

- Evaluating health effects: If there is evidence that people are being exposed—or could be exposed—to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. The report focuses on public health—the health impact on the community as a whole—and is based on existing scientific information.

- Developing recommendations: In the evaluation report, MDH outlines its conclusions regarding any potential health threat posed by a site, and offers recommendations for reducing or eliminating human exposure to contaminants. The role of MDH in dealing with hazardous waste sites is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies—including EPA and MPCA. However, if there is an immediate health threat, MDH will issue a public health advisory warning people of the danger and will work to resolve the problem.

- Soliciting community input: The evaluation process is interactive and ongoing. Typically, MDH begins by soliciting and evaluating information from various government agencies, the organizations responsible for cleaning up the site, and the community surrounding the site. Any conclusions about the site are shared with the groups and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, we encourage you to contact us.*

Please write to: Community Relations Coordinator
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Summary

Two teenagers brought mercury from an industrial site into a manufactured home park and, with about 14 additional children, played with the mercury for about 2 hours. The children splashed in puddles of mercury on an outdoor basketball court, threw mercury at each other, and mercury was even poured into the hair of some children. Quick action by a parent and local authorities resulted in decontamination of most of the children within 10 hours of the initial event. Thirty-eight individuals were removed from their homes the first night.

In all, 14 children were examined by physicians. Six children exhibited elevated mercury levels in blood; however none needed to be treated. Thirteen homes needed to be decontaminated. All families were returned to their homes within 22 days. At one point, a motor vehicle that was not completely cleaned was returned to a family, resulting in the recontamination of about 5-6 people, including 3 children.

MDH provided consultation for responding agencies, local public health officials and physicians who examined exposed individuals. The Minnesota Pollution Control Agency supervised the cleanup of contaminated homes, motor vehicles and personal belongings. Prior to be returned to their owners, these items were cleaned to clearance levels recommended by MDH and based on the EPA mercury reference concentration and the California acute reference exposure level.

Introduction

This health consultation reviews an elemental mercury spill incident where children played with mercury and tracked it into their homes. The incident required response from Rosemount Police and Fire Departments, Dakota County Sheriff's Department, Dakota County Health Department, Dakota County Environmental Services, Dakota County Special Operations Team, the Minnesota Pollution Control Agency (MPCA), the Minnesota Department of Health (MDH) and the US Environmental Protection Agency. The last contaminated house was cleared for re-occupancy 22 days after the incident began. The incident was an Urgent Public Health Hazard that required a rapid cooperative and coordinated response by all agencies and interested parties. Technical assistance and consultation provided by MDH addressed the following: the need for medical screening; evaluating individual exposures; the environmental chemistry of mercury; quality assurance and control issues related to the use of real-time mercury vapor analyzers; evacuation criteria; re-occupation criteria; vehicle clearance criteria; personal property clearance, and risk communication. Information about the health surveillance during this event has been previously reported in Morbidity and Mortality Weekly Reports (Baker et al., 2005; Attachment 1).

Background

On Labor Day, Monday September 6, 2004, two teenagers discovered a large amount of elemental mercury (3/4 quart, or 21 pounds) at the Brockway Glass Company, which is being prepared for demolition in Rosemount, Dakota County, Minnesota (Attachment 2). They took the mercury to Rosemount Woods, a manufactured home park about ¼ mile south of the site. The teenagers and 12 other children played with the mercury, pouring it, throwing it at each other and splashing in a large puddle of mercury on an outdoor basketball court. The initial exposure was limited to less than 2 hours as a result of quick thinking and action by a parent who contacted police and told the children to go home and shower.

The Dakota County Special Operations Team, which specializes in apparatus decontamination, decontaminated forty-eight individuals, including 18 children within 8 hours after the initial exposure. Decontamination was accomplished by thoroughly scrubbing individuals with water and detergent. Decontamination of residents was completed at 1:52 AM Tuesday morning. Because mercury vapor exposures occurred outdoors, exposures were of relatively short duration, and the individuals exposed were decontaminated, MDH did not advise individuals to be evaluated in an emergency room. However, concerned individuals were advised to see their own physicians. Thirty-eight people were displaced on Monday night and were housed in a motel by the American Red Cross.

Beginning at about 9 PM the night of the incident, homes of exposed children and other homes in the manufactured home park were scanned for contamination using a realtime mercury vapor analyzer (Lumex; RA-915+, OhioLumex Company, Twinsburg, Ohio). Out of 179 homes evaluated, 13 houses were found to be contaminated with mercury above levels of concern. Exposed children lived in ten of the contaminated houses; 3 additional houses were apparently contaminated when adults tracked mercury into them. In addition, 4 motor vehicles were also found to be contaminated.

The morning after the event, MDH staff accompanied Rosemount Police and Dakota County Sheriff deputies and interviewed 11 children and their parents, asking questions pertaining to exposures that took place during the event. About 24 hours after the initial incident, a mercury surveillance team with a Lumex was asked to check motel rooms occupied by the displaced families. Rooms occupied by a number of families were found to be contaminated. Decontamination of the motel, and further decontamination of children (by parentally supervised showering) was required. In addition, because the initial decontamination was found to be incomplete and because of additional exposure information uncovered while questioning the children, MDH recommended that exposed children be examined by their own doctors, or a doctor specializing in occupational medicine, within 24 hours.

Cleanup of all contaminated houses was completed 22 days after the initial exposure. The Minnesota Pollution Control Agency used a mercury-sniffing dog (MPCA, 2004) to find the source of contamination in the last house cleared. Three of the four contaminated motor vehicles were not cleanable and were scrapped.

Elemental mercury: a human health hazard

Considerable information is available on the MPCA mercury website about mercury in the environment, contamination and cleanup (http://www.pca.state.mn.us/air/mercury.html).

Mercury in the environment

Elemental mercury can be found in soil, water, and air. Elemental mercury is the only metal that is a liquid at room temperature. In addition, elemental mercury is volatile. Mercury vapor exposures occur when elemental mercury is spilled or left uncovered.

Mercury volatilizes very slowly. If air overlying a spill is replaced rapidly, the mercury concentration will not build up to dangerous levels. On the other hand, in a closed room mercury vapor concentrations from even a small spill can reach dangerous levels. As a result, outdoor spills are typically of little vapor-related health consequence. Outdoor spills are mainly a concern because elemental mercury can be slowly converted, over time, into methyl mercury that can be incorporated into the aquatic food chain. The highest concentrations of methyl mercury are found in large, predatory fish that may be consumed by people, resulting in exposure to mercury. While a mercury spill could certainly result in a large exposure to some individuals, the consumption of large, predatory fish is the largest source of mercury exposure for the general public.

Methods for measuring mercury vapor in the environment

Historically, mercury vapor has been measured by drawing air through a cell, or tube, that changes color relative to the mercury concentration in the air. These hopcalite cells are not very sensitive and require large volumes of air to measure a mercury concentration in air. Measuring air concentrations at a single location in a house can take 8 hours. In addition, hopcalite cells are expensive, and each hopcalite cell can only be used once. The development of realtime mercury vapor analyzers, such as the Lumex, has allowed investigators to repeatedly measure mercury vapor concentrations in seconds.

Locating and cleaning mercury contamination

Elemental mercury vapor, unlike the vapors of most volatile organic contaminants, does not readily condense. Instead it remains a vapor until it is converted to a reactive gaseous species and is stripped from the atmosphere by wet or dry particulates and aerosols (EPA, 1997). The half-life of mercury vapor in the atmosphere is about 1 year. Once volatile, significant amounts of mercury will not condense in a room or house. Therefore it will not form residues throughout the building. Pinpointing the source of contamination and removing the source is the best way to lower mercury vapor concentrations indoors. Scrubbing an entire carpet, or cleaning the walls will not necessarily decrease mercury vapor concentrations within a building while removing even a small source can make a big difference.

Realtime mercury vapor analyzers, such as the Lumex, are very useful for finding mercury sources. In a room with some air movement, it is likely that mercury vapor inches from a mercury source will be a much higher concentration than mercury vapor concentrations in the breathing zone or in other places in a room. Outdoors, a realtime mercury vapor analyzer is less useful. If the ambient concentration in the room or house is low enough, a mercury-sniffing dog like the MPCA’s Clancy (MPCA, 2004) can often find a mercury source much quicker than an instrument operator.

Seven Lumex (RA-915+) analyzers were used during this incident. The instrument is capable of reporting concentrations to an attached display in 3 different time intervals: 1-second sampling; 10-second mean, and; the mean of 3 x 10-second readings. While 1-second reporting intervals are handy for scanning an area and trying to locate a spill, MDH recommends recording 30-second results when characterizing mercury vapor concentrations at any specific location. The Lumex requires about 20 liters of air per minute for analysis.

Air exposures and health

Dermal (skin) exposure to mercury and ingestion (swallowing) of mercury are unlikely to be significant sources of exposure, because dermal and gastrointestinal absorption of elemental mercury is limited (ATSDR, 1999). Therefore, vapor exposures to elemental mercury spills are typically of greatest concern to MDH.

MDH recommends safe chemical exposure criteria for the general public and individuals with no expectation of workplace exposure. MDH uses health-based reference values from different organizations, based on availability, in the following preferential order: MDH Health Risk Values (HRVs), EPA Integrated Risk Information System (IRIS) reference concentrations (RfCs), and provisional RfCs and other health-based values, such as Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs) and California Reference Exposure Levels (RELs).

Chronic Air Exposure Reference Values for Elemental Mercury

EPA's integrated risk information system (IRIS) database specifies an RfC for chronic exposure to mercury vapor of 300 ng/m^3 (EPA IRIS, 2003). An RfC is an exposure concentration that is not expected to result in adverse health effects to most people, including sensitive subpopulations, exposed over a lifetime. The mercury RfC is derived from multiple studies of occupational exposures. Most studies were conducted with employees in chlor-alkali or fluorescent light bulb plants who were exposed to mercury vapor. The observed critical effects included hand tremors, memory disturbances, and slight subjective and objective evidence of autonomic nervous system dysfunction. The lowest observable adverse effects concentration (LOAEC) in the occupational studies used by EPA to develop the RfC was 25,000 ng/m^3. Affected workers had mean whole blood mercury concentrations of 10–12 micrograms per liter (µg/L). Adjusted to a 24 hour, 7 days per week exposure, the adjusted lowest observable adverse effect concentration ($LOAEC_{adj}$) = 9,000 ng/m^3. An uncertainty factor of 10 is applied to compensate for the use of a LOAEC (as opposed to a concentration at which no effects are seen) and for variations in human sensitivity, and an uncertainty factor of 3 for lack of studies on the reproductive and developmental effects of elemental mercury. The resulting RfC (300 ng/m^3) is assumed to be a safe average exposure level for a lifetime.

The calculation of an RfC assumes that there is a threshold level for effects. A threshold for toxicity from mercury vapor exposure is presumed in the standard model used by EPA for noncarcinogens.

The California Office of Environmental Health Hazard Assessment (CA OEHHA) derived a Reference Exposure Level (REL) for chronic inhalation exposure to mercury from the same studies used to develop the IRIS RfC. However, instead of using the cumulative uncertainty factor of 30 used by EPA, CA OEHHA has adopted an uncertainty factor of 100. This is based on a factor of 10 for the uncertainty of using an LOAEC exposure instead of a "no observable adverse effects concentration" (NOAEC) when calculating the REL. It also includes a factor of 10 for human intraspecies variability. The California REL for mercury (elemental and inorganic) is 90 ng/m^3 (CA OEHHA, 2001).

The Agency for Toxic Substances and Disease Registry (ATSDR) has a health-based chronic minimum risk level (MRL) for mercury of 200 ng/m^3 (ATSDR, 1999). This MRL is calculated from the same data used to calculate the IRIS RfC. However, the MRL calculation assumes that in an occupational exposure, one third of the daily inhaled air each working day is contaminated. The EPA RfC assumes that half of the working daily inhalation is contaminated.

MDH uses IRIS RfCs for giving exposure advice when there is not an HRV. MDH has some concern that the EPA RfC uncertainty factor of 30 may not sufficiently protect sensitive subpopulations given that the basis of the underlying value is an LOAEC. The California chronic mercury REL does provide this additional protection. However, practical application of the mercury REL at contaminated sites may be problematic because personal exposure to mercury from other sources, including dental amalgams, may be in the range of the REL. MDH therefore recommends that the EPA criterion be used, but that care be taken to ensure that chronic exposures to mercury from all sources do not exceed this level.

Acute Air Exposure Reference Value for Elemental Mercury and Inorganic Salts

California OEHHA developed an acute REL for mercury vapor based on developmental effects in the offspring of exposed rats. Central nervous system effects in pups were noted following exposure of dams to 1.8 mg/m^3 for 1 hour/day during gestation. A cumulative uncertainty factor of 1,000 is attached to this REL because it is based on a LOAEC (10x), the primary study was an animal study (10x), and human response to all chemicals is variable (10x).

The CA OEHHA acute REL for mercury vapor is 1,800 ng/m^3, with a critical endpoint of reproductive or developmental effects (CA OEHHA, 2001).

Soil and Water

As noted above, mercury spills rarely result in direct dermal or ingestion health concerns. However, mercury spilled in the environment can be washed into aquatic systems, or it can volatilize and be transported to other watersheds where it can be deposited. Once in the aquatic environment, mercury is methylated by sulfate-reducing bacteria and may enter aquatic food chains. Methylmercury accumulates in the food chain, especially in fish which are then consumed by people (see Chapter 6 EPA, 2001 for review). This indirect route-of-exposure to mercury in the environment is the largest source of mercury exposure for most people (excluding individuals exposed to high concentrations as a result of an elemental mercury spill). While the contribution of a single spill to the global food chain is extremely small, MDH and MPCA along with other state and federal agencies support a general policy of minimizing mercury releases to the environment.

MPCA has developed health-based residential chronic, child sub-chronic, and industrial chronic Soil Reference Values (SRVs) of 0.7, 0.8, and 2 parts per million (ppm) mercury, respectively. MDH concurs with the use of these criteria as soil cleanup levels. MDH also recommends 0.02 ppm mercury as a sediment screening value (MDH, 2004a; URS Corporation, 2003).

In addition, MPCA has surface water and groundwater criteria for mercury. Typically, surface water and groundwater criteria for mercury are not relevant criteria for elemental mercury spills because elemental mercury is sparingly soluble.

Investigation of Exposures

Interviews
Initial reports to MDH were that exposures to elemental mercury appeared to take place outdoors. The children were throwing mercury around and splashing in a large puddle of mercury. Furthermore, it seemed apparent that the quick action by a parent had limited the exposure to a relatively short duration. The children also underwent decontamination within 6-10 hours after the exposure began. These reports suggested that the children's exposures, while potentially significant, were limited and had ceased. As a result (on advice from MDH), families were told the night of the incident that they should see a physician only if they were concerned. However, medical examination of exposed individuals was not initially required.

Even with the prompt decontamination MDH remained somewhat concerned because the children may have been exposed in unlikely, but dangerous ways to the mercury as they played with it (such as drinking or heating the mercury), it was possible that not all of the mercury had been collected by authorities, and not all of the children may have been identified. Therefore, MDH staff accompanied Rosemount Police and Dakota County Sheriff Deputies the following morning to interview the two teenagers who took the mercury, and other children known to have played with it, and their parents.

Table 1 is a list of the questions MDH asked about the incident.

Table 1: Interview questions

Name, age, address
* When did you go into the factory?
* Who else was there?
** Where were you when you saw or played with the mercury?
How much mercury did you see?
Did you take any? How much did you take?
Where did you take it?
What did you do with it? How use? When?
What parts of your body touched it?
Did you show/give to another?
How much? Who?
Where did you go afterwards?
House? Who's? Car? Other?
Did you touch/play with anyone or anything after you quit playing with the mercury?
Where are the clothes/shoes you wore?
Did anyone try to taste the mercury?
Did anyone play with the mercury near a fire or cigarette - or heat it up?
Do you eat fish?
Did you get decontaminated?

* Questions only for the teenagers who took the mercury from the factory
** Questions for all children who may have come in contact with the mercury

Generally:

- the children and parents identified 16 children who may have been exposed (including 2 who were previously unidentified and had not been decontaminated);
- the teens in possession of the mercury went to a couple of homes to show it to friends prior to going to the basketball court;
- many of the children had mercury poured over their heads and in their hair;
- some children tried to collect and save some mercury;
- nobody tried to taste the mercury;
- 1 youth tried to light the mercury with a lighter, and;
- most of the children eat fish rarely.

As a result of the questioning, MDH recommended that some of the children be evaluated by a physician. Of primary concern were children who were present when the mercury was heated with a lighter and those who had mercury poured in their hair. Heating mercury increases the rate that mercury volatilizes and the potential for dangerous exposures to mercury vapor; and mercury in hair is not likely to be removed by conventional decontamination procedures, potentially resulting in continuing inhalation exposure to elemental mercury as it volatilizes from hair.

Later in the afternoon following the incident, motel rooms occupied by displaced families were found to be contaminated. In addition, air next to the hair of 3 of the children was found to have high concentrations of mercury (Table 2). These data suggested that some of the children's exposures were continuing, and that decontamination was incomplete. All children were advised to shampoo their hair and to see an occupational medicine physician. As a result, all fourteen children known to have been exposed were examined by physicians.

Table 2: Mercury Vapor Concentration next to Hair and Chest (ng/m^3) *

Patient	Hair				Chest	
ID#	**24 hrs**	**42 hrs**	**43 hrs**	**98 hrs**	**42 hrs**	**98 hrs**
1	635 **	1742		664		
2		376		142	597	454
3		430		327	546	1662
4		381		38	128	48
5		1247		169		273
6	17000 **	4812	2690	94	1634	62
7		9681	873	3926	1384	1163
9		283		106	424	254
12	35000 **		850			

Some children (nos. 8, 10, 11, 13, 14) were not available for mercury vapor sampling.
* All samples (except those indicated) are the mean of 3 - 10 second averages (Lumex)
** Sample presumed to be 1 second maximum (Lumex)

Blood samples were drawn at least once from 14 exposed children 2-15 days after exposure (Table 3, below) and 24-hour urine specimens were taken from 7 children as well (Table 4, below). In addition, some of the children who visited the Regions Hospital Occupational Medicine Clinic (St. Paul, MN) were scanned with a Lumex to measure the mercury vapor concentration near their hair, near their skin (chest and hands) and in their exhaled air. All children were asked to return for a second appointment to discuss blood and urine sample results, and for a second round of blood sampling. Two days after the hospital visit, seven children were scanned with the Lumex for a second time.

Biological sampling

Normal measures in US population

Mean blood and urine mercury concentrations in two studies of workers exposed to 25,000 ng/m^3 for many years are 10 and 17 µg/L in blood, and 12 and 20 µg/L in urine (EPA IRIS, 2004). Neurological studies on these workers showed significant exposure-related effects. Geometric mean and 95 percentile total blood mercury concentrations in the 1999–2002 National Health and Nutrition Examination Surveys (NHANES) for women of childbearing age were 0.92 and 6.04 μg/L, respectively, and for young children were 0.33 and 2.21 μg/L, respectively (Jones et al., 2004). Almost all inorganic mercury blood concentrations in this study of the NHANES data were below the detection level of 0.4 μg/L. Geometric mean and 95th percentile concentrations of urine mercury for women aged 16–49 years in the 1999–2000 NHANES data were 0.72 and 5.00 μg/L, respectively (US Department of Health and Human Services, 2003). These data suggest that it is reasonable to expect that normal blood mercury for the general population is below 6 μg/L and normal urine mercury is below 5 μg/L. Normal exhaled air mercury concentrations are typically less than 50 ng/m^3 for individuals without dental amalgams (Herbrandson and Hubbard, unpublished observations).

Incident-related medical examinations and data

No patient showed symptoms that could be explained only by mercury vapor exposure, but two patients complained of new-onset coughs and one patient did not have an appetite in the 2 days following the event. While coughs and loss of appetite are consistent with a significant acute mercury exposure, late-night decontamination and apprehension about the first day of school may result in similar symptoms. By the time that these three patients had their second examination, the problems with coughs and decreased appetite had gone away. Table 3 contains data on testing of blood from exposed children (Day 2 blood samples from patients #6 and #14 clotted and therefore were not analyzed). These data show that at least 7 patients had a significant exposure to mercury. The data also show a relatively rapid decline in blood mercury values.

Table 3: Mercury in Blood

Patient ID#	Day 2	Day 4	Day 7	Day 9	Day 10	Day 11	Day 15
	(μg/l)						
1	**9**						< 5
2	**9**				< 5		
3	**13**				< 5		
4	< 5		< 5				
5	< 5		< 5				
6	*						
7	**12**				< 5		
8				< 5			
9	**8**			< 5			
10						< 5	
11	< 4						
12	*				**6**		
13		**5**					
14							< 4

* Blood clotted and was not analyzed.

Seven 24-hour urine samples were collected and analyzed (Table 4). Although measurable concentrations of mercury were detected in urine, they did not exceed levels of concern.

Table 4: Mercury in Urine (24-hour creatinine normalized)

Patient ID #	Day 5 (µg/g C)	Day 7 (µg/g C)	Day 10 (µg/g C)	Sample Volume (ml)
1	3			850
2	7			300
3			6	750
6		6		*
7	5			350
9		< 10		*
12	< 10 (no date)			450

* Laboratory categorized as "random" because the samples were apparently not consistent with 24-hour urine samples.

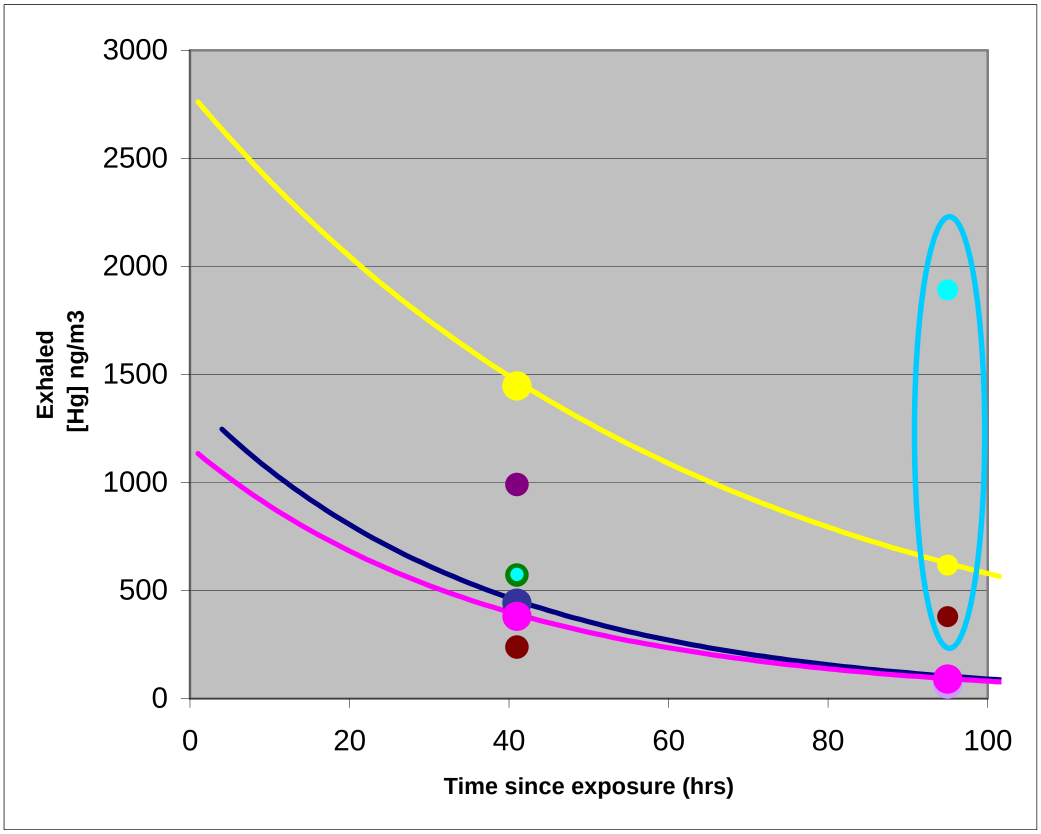
Eight children were asked to blow up plastic bags with air. The mercury vapor concentration in the bagged air was then measured with the Lumex. Table 5 shows exhaled air mercury concentrations. Note the decrease over time for 3 children; and note that 2 children showed an increase over time. This was due to re-exposure following the spread of contamination from a motor vehicle. Children who were not re-exposed showed a decrease in the amount of mercury vapor exhaled, with a half-life ($t_{1/2}$) of 25-26 hours. One individual (#7) found to have been re-exposed had a longer measured $t_{1/2}$. Figure 1 shows exhaled mercury vapor over time. Circled data points are data from children re-exposed within the preceding 8 hours.

Table 5: Exhaled Mercury

Location:	Hospital	Motel	$t_{1/2}$*
Time:	44 hrs	98 hrs	
Patient ID#	(ng/m^3)	(ng/m^3)	(hours)
1	571		
2	990		
3	575	1890 †	§
4		66	
5	380	90	26
6	442	101	25
7	1,446	616 †	44
9	239	379 †	§

* half-life of exhalation
† individual re-exposed
§ exhalation increased

Figure 1: Exhaled mercury concentration vs time



Available data (blood, urine, and exhalation) indicate a significant initial exposure followed by decontamination. Some of the children recontaminated and re-exposed on day 4. The last blood mercury measurement for all children, except #12, showed concentrations below reporting levels (4–5 µg/L), suggesting that the exposure had ended. Patient #12 had the highest level of exposure as measured by mercury concentration in air next to the hair, 6 µg/L blood mercury on day 10, and a urine concentration of less than 10 µg/g creatinine. No treatment was indicated for any patient.

No significant relation was found among measurements of mercury levels in blood, urine and exhaled air.

Discussion

Individual exposures
Blood half-lives published in the literature for individuals exposed to mercury vapor (Cherian et al., 1978; Barregard et al., 1992) are consistent with the decline in blood seen in this incident. This rapid decline in blood mercury suggests that the source was from mercury vapor because the blood half-life of methyl mercury, acquired from fish consumption, is much longer: about 90 days for children (Swartout and Rice, 2000; adult blood methyl mercury half-life is about 50 days).

About 7.4% of inhaled mercury is exhaled in the first 3 days following exposure (Hursh et al., 1976; Sandborgh-Englund et al., 1998). Table 3 shows the exhaled mercury concentrations in air in plastic bags blown up by exposed children 2 and 4 days following this incident. A wide range of values was observed in these individuals who were assumed to be similarly exposed (range: 1890 - 60 ng/m^3). This is due to: 1) unidentified differences in exposure; 2) differences in rates of mercury vapor loss by exhalation, or; 3) differences in technique used to blow up a plastic bag. It is likely that individual children were exposed to different extents during this event. For example, the children with mercury in their hair were likely exposed for a longer period of time. In addition, differences in the rate at which mercury is metabolized or taken up by tissue could significantly affect the exhalation rate at any time.

Because it is probable that an individual will blow up a bag the same way each time, differences in technique is a less likely confounder for intra-individual measurements. Table 5 shows that exhaled mercury concentrations for children who were not re-exposed decreased with a half-time of 25-26 hours. This is similar to decreases seen in studies by (Hursh et al., 1976) and (Sandborgh-Englund et al., 1998), where mercury exhalation following a single exposure decreased with a half-time of 13 to 25 hours and 1.6 to 2.3 hours, respectively.

The lack of correlation between exhaled mercury and blood mercury from children exposed during this incident is likely caused by: measurement of different forms of mercury (total mercury for blood and elemental mercury for exhaled) and the small range of exposures.

It is expected that 9.7% and 2.4% of inhaled mercury is excreted in feces and urine, respectively, in 7 days (Cherian et al., 1978). While a 24 hour urine sample measures elimination over a relatively long time period, the small amount excreted by this route makes it difficult to interpret data following a single acute exposure. On the other hand, if levels in the body reach steady-state during a chronic exposure to mercury vapor, urinary mercury measurements (which indicate mercury levels in the kidney) are more useful. Mercury concentration in feces is not typically analyzed.

The individual who may have had the highest exposure in this incident (#12) had a relatively low blood mercury and an inconclusive urine mercury. A blood sample from this individual was drawn less than 30 hours after the incident, but the sample clotted and analysis was not performed. The relatively low blood mercury (6 µg/L) was drawn on day 10, possibly 2-5 half-lives after the blood concentration peaked. In addition, this patient's urine was sent to a laboratory with a high reporting limit (10 µg/L). All children and their families were very inconvenienced during the incident. Therefore, care was taken not to disturb them unless it was absolutely necessary. As a result, this patient was never tested for mercury in exhaled breath.

Sampling and cleanup of dwellings and personal possessions
Cleanup was accomplished by disposing of 'soft' items (such as upholstery and clothing) that were contaminated. Carpeting was removed from many of the contaminated homes. Floors and walls were sometimes scrubbed. Bathroom tile was difficult to clean, and some drains were also contaminated and their traps were replaced. The MPCA tried to clean contaminated clothes with a used washer and dryer purchased specifically for this purpose. In general, contaminated clothing was not successfully cleaned and was discarded.

MDH was asked to determine cleanup criteria for homes, motor vehicles and personal belongings. MDH recommended that homes were safe for reoccupancy when 10-second average mercury vapor samples were below 500 ng/m^3 throughout the dwelling. In addition, MDH recommended that contaminated motor vehicles were safe for repossession when mercury vapor concentrations were below 1000 ng/m^3. MDH recommendations for methods to be used when clearing homes and automobiles for re-occupancy are described in a September 16, 2004 memo from MDH to the Dakota County Department of Public Health (2004b; Attachment 3). These cleanup criteria, or clearance concentrations, for Rosemount Woods were based on limiting an individual's maximum average exposure to no more than the EPA's chronic Reference Concentration (RfC) of 300 ng/m^3 and the acute California Reference Effects Level (REL) of 1800 ng/m^3.

MDH also recommended that short term mercury vapor exposures from contaminated personal belongings should not exceed 1800 ng/m^3, and long-term exposures should not exceed 300 ng/m^3. Therefore agencies involved decided that if a plastic bag containing a personal item had a mercury vapor concentration exceeding about 1200 ng/m^3, restricting access to the item would be considered. However, no definitive policy for sampling and returning personal possessions was developed. Eventually, people were instructed as to the potential hazards and allowed to make their own decisions about irreplaceable personal items.

All thirteen contaminated houses were successfully cleaned to recommended levels. Three of four contaminated cars were 'totaled' because they could not be cleaned below a clearance level of 1000 ng/m^3.

General Lessons Learned

Mercury spills are difficult to cleanup because most commonly employed methods to clean items and structures (e.g. sweeping, vacuuming) disperse mercury, increasing the surface area of the mercury, increasing evaporation, and making the contamination worse.

The availability of realtime, portable mercury vapor analyzers, such as the Lumex, allows investigators to detect mercury wherever it is spilled. This provides some measure of assurance that unsuspecting individuals will not suffer from exposure to incompletely cleaned mercury spills, but it also increases the necessary commitment to cleaning up spills.

Blood can be a good measure of an acute mercury vapor exposure because well-timed measurements will show an exposure spike. Furthermore, blood measurements over time can be used to show a reduction or cessation of exposure. However, physicians need to be aware that the half-life of mercury (from vapor) in blood is relatively short (2-5 days) and it is likely that the peak blood mercury concentration will be missed under most accidental exposure scenarios.

Exhaled mercury concentration can provide immediate information about whether or not an individual has been exposed to mercury vapor. Data from this incident does not show good consistency in exhalation concentrations between individuals that were assumed to have similar exposures. However, repeated measurements of exhaled breath from the same individuals over 12 to 24 hours can show if exposures have changed. In addition, exhaled mercury concentrations may be useful in triaging patients. Perhaps the biggest advantage to exhaled mercury measurements is the quick turn-around time. Doctors who took blood and urine samples during this event did not have analytical results until 7 days after samples were drawn. On the other hand, realtime mercury vapor measurements from the children's hair and exhaled breath prompted MDH to recommend further decontamination of these children through repeated shampoos and showers.

Urine mercury measurements are very useful when trying to characterize a long or continuing exposure because urine concentrations will be somewhat stable and are likely a better measure of tissue concentration than blood mercury. However, when the duration of exposure is short, urine mercury will only increase slowly over time and only small fraction of total inhaled mercury is excreted in urine. Therefore, urine mercury may not show a spike during or soon after exposure.

Exhaled breath, blood and urine can all be useful in determining exposures to mercury. Investigators need to be aware of the potential for mercury amalgams, fish consumption, medicinal and ritualistic uses of mercury to confound analytical results (ATSDR, 1999).

This mercury incident created an Urgent Public Health Hazard, as defined by the Agency for Toxic Substances and Disease Registry. MDH's role during the emergency event was focused on determining whether or not exposures were hazardous, and whether exposed individuals should be advised to see a physician. During the recovery, or cleanup phase after the initial incident, MDH's attention was focused on surveillance of the exposed individuals, with attention on reducing biological indicators of exposure, and; consultation to agencies responsible for the cleanup and local public health, to assure that public health was protected.

Four general MDH recommendations are a result of specific lessons learned during the Rosemount Woods incident.

1. Mercury and other hazardous wastes at abandoned or vacant facilities should be secured and removed promptly.
2. The success of decontamination during an emergency event should be monitored and confirmed. Field instruments, such as the Lumex, are ideally suited for this.

3. Field instruments are extremely useful during cleanup; however, appropriate training of operating personnel in tracking contamination and exposure is very important.
4. Quality assurance and quality control of instrumentation, data collection and public health surveillance are important aspects of an emergency response action.

Conclusions

The incident was an Urgent Public Health Hazard that required a rapid cooperative and coordinated response by all agencies and interested parties. Technical assistance and consultation provided by MDH addressed the following: the need for medical screening; evaluating individual exposures; the environmental chemistry of mercury; quality assurance and control issues related to the use of real-time mercury vapor analyzers; evacuation criteria; re-occupation criteria; vehicle clearance criteria; personal property clearance, and risk communication.

Recommendations

No further site specific actions are recommended.

MDH will continue to provide advice and communications assistance when mercury is spilled.

Public Health Action Plan

The health department fills an important role by: helping the public evaluate their own exposure; providing information to physicians to help them estimate patient exposures; providing environmental chemistry and cleanup support to the environmental agencies, and; providing local public health officials with the best information and recommendations on the risks that may come from exposure under different conditions.

The Rosemount Woods incident was a good example of state public health officials working closely with law enforcement, emergency management, hazardous waste management and local public health practitioners to quickly reduce the exposures of the public to a hazardous chemical.

Actions Taken

These MDH-recommended actions were taken to address the Rosemount Woods incident; they may be applied to other mercury spill incidents.

1. If mercury vapor concentrations in a home exceed 1000 ng/m^3, residents should be evacuated.
2. Use a realtime mercury vapor analyzer (e.g. Lumex) to demonstrate that exposures have ceased. This includes measuring mercury vapor near skin and hair, as well as exhaled mercury.

3. Acquire and record 3 x 10 second averages from the Lumex rather than the maximum 1-second reading when characterizing mercury vapor concentrations.
4. Homes are safe for reoccupancy when mercury vapor levels throughout the closed house do not exceed 500 ng/m^3.
5. Automobiles are safe to use when measured mercury vapor levels are below 1000 ng/m^3.
6. While use of discretion is important in deciding what to do with personal items, general guidance for returning personal property to individuals is that mercury vapor in a bag containing the item should not be above 1200 ng/m^3.

In addition, MDH recommended the following to physicians about biomonitoring and treatment of individuals exposed during this incident:
1. Sample whole blood and 24-hour urine specimens for total mercury.
2. Conduct follow-up sampling after about 1 week for individuals with levels of mercury in blood or urine above reporting limits to confirm decreasing mercury levels in biomakers of exposure.
3. Confer with an occupational physician (and a pediatrician if the patient is a child) before considering chelation therapy for anyone exposed to mercury vapor.

MDH did not recommend longterm followup of exposed individuals, because the quick response limited exposures.

This Health Consultation was prepared by:

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Certification

This Rosemount Woods Mercury Incident Health Public Health Consultation was prepared by the Minnesota Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodologies and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

Technical Project Officer, CAT, SPAB, DHAC

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.

Alan W. Yarbrough

Team Lead, CAT, SPAB, DHAC, ATSDR

parked MVs, 2) drivers should look carefully for children before and while backing up, and 3) MVs should be locked in garages or driveways with keys kept out of reach of children (*6,8*). Potential environmental modifications include fenced driveways, fenced play areas away from driveways and streets, and circular driveway designs that eliminate the need to back out. Potential automobile modifications include back-up warning alarms when vehicles are placed in reverse or mirrors, sensing devices, or cameras to alert drivers to out-of-sight objects, such as small children (*1*). Research is needed to determine the effectiveness of such approaches.

Data from injury surveillance systems such as NEISS-AIP highlight the preventable morbidity and mortality resulting from MV-related backover injuries in children. Effective engineering and environmental approaches to prevent MV-related backover injuries need to be identified, evaluated, and disseminated to public health and transportation officials and policy makers for implementation nationwide. Meanwhile, drivers and caregivers can take simple precautions to prevent these injuries. To this end, child MV safety programs and health professionals should ensure that parents, caregivers, and the public are aware of the risks for injury associated with MV backovers and appropriate prevention measures.

Acknowledgments

This report is based on information contributed by T Schroeder, MS, C Irish, and other staff, Div of Hazard and Injury Data Systems, US Consumer Product Safety Commission. K Gotsch, MPH, P Holmgreen, MS, Office of Statistics and Programming, National Center for Injury Prevention and Control, CDC.

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Measuring Exposure to an Elemental Mercury Spill — Dakota County, Minnesota, 2004

Elemental mercury spills can cause contamination of neighborhoods and homes and result in neurologic and kidney disorders in exposed persons who inhale mercury vapors. Often, however, difficulties exist in determining the magnitude of exposure and effectiveness of decontamination or in recognizing that reexposure has occurred. This report summarizes the response to an elemental mercury exposure that resulted in the decontamination of 48 persons and the subsequent analysis of blood and urine samples from 14 exposed youths aged 6–16 years. Data from these analyses suggest that 1) blood samples are more sufficiently acquired and can be used to evaluate recent acute exposure and 2) use of a real-time mercury vapor analyzer can help public health officials determine the magnitude of exposures and help prevent reexposures. In addition, demolition and waste-disposal firms and government agencies must take actions to ensure that elemental mercury is adequately secured before disposal.

Case Report

In preparation for demolition of a factory in Dakota County, Minnesota, hazardous waste from the factory was temporarily stored in a shed, which was not effectively secured. During a late afternoon in September 2004, two teenagers entered the shed and found two canning jars containing approximately 21 pounds of elemental mercury. The teenagers brought the mercury back to their neighborhood, where they and approximately 12 other youths played with it, throwing handfuls of mercury at each other and splashing in a large puddle of mercury on an outdoor basketball court. This initial exposure was limited to <2 hours because of rapid response by a parent who saw what the youths were doing, told them to go home and shower, and contacted the police. Subsequently, 48 persons, including 18 youths, were decontaminated with water and detergent by the Dakota County Special Operations Team between 10 p.m. and 2 a.m. Beginning at 9 p.m., homes were scanned for contamination by using a real-time mercury vapor analyzer (RA-915+; Ohio Lumex Company; Twinsburg, Ohio). On the recommendation of Minnesota Department of Health (MDH) staff, residents of 12 contaminated homes* were sheltered in a motel by the American Red Cross.

* In this incident, MDH recommended evacuation of homes with a maximum mercury vapor concentration >1,000 ng/m^3 and recommended cleanup of all homes with a maximum concentration (unventilated) >500 ng/m^3, as measured by a mercury vapor analyzer. Cleanup or disposal of vehicles was recommended at concentrations >1,000 ng/m^3. These cleanup/clearance criteria were intended to limit exposures to no more than the Environmental Protection Agency chronic reference concentration of 300 ng/m^3 or the acute California reference effects level of 1,800 ng/m^3.

As part of its epidemiologic investigation, MDH staff interviewed some of the youths the morning after the event and learned that the teenagers had attempted to ignite the mercury and might have been exposed to fumes. Subsequent sampling with the mercury vapor analyzer in motel rooms of displaced families revealed mercury contamination, and high concentrations of mercury vapor found near the hair of three youths 24 hours after exposure (Table 1) suggested that exposures might have been more severe than initially indicated, that decontamination was incomplete, and that exposures were continuing. Consequently, 14 youths aged 6–16 years with known exposures were examined by physicians; 11 were evaluated at Regions Hospital in St. Paul, Minnesota.

Blood and/or urine samples were obtained from all 14 youths. However, although the youths were provided bottles for urine samples when their blood was drawn, the first samples were not provided until 3 days later, during the weekend. In addition, at Regions Hospital and at one extended-stay motel, mercury vapor concentrations were measured with a mercury vapor analyzer near the skin of the youths, and exhaled air mercury vapor concentrations were measured by analyzing air in plastic bags inflated by some of the youths. Contaminated hair and scalps of the youths were washed at the hospital with shampoo containing selenium sulfide and dried with terry-cloth towels, which were then discarded. Decontamination was verified with a mercury vapor analyzer. Follow-up samples were obtained for youths with elevated mercury levels.

Epidemiologic and Sampling Findings

All 14 patients had routine physical examinations. Two had new onset cough, and one complained of a poor appetite; these symptoms had resolved by a follow-up visit. Samples from four youths were taken at different times because not every patient agreed to provide a blood sample on day 2. In addition, blood samples drawn from two youths on day 2 coagulated; one of these persons was retested on day 10. Elevated mercury (≥8 μg/L) was found in five of eight analyzed blood samples taken on day 2 (Table 2). Additionally, measurable amounts (5 μg/L and 6 μg/L, respectively) of mercury were found in samples collected from one child on day 4 and another child on day 10. Second blood samples collected during days 9–15 from the five youths with the initial elevated readings determined their blood mercury levels had declined below the laboratory reporting limit (5 μg/L). Second blood samples could not be obtained from two youths. Measurable mercury was found in the urine samples of five youths (Table 2). However, these urine sample results might be unreliable because of small sample volumes.

From hour 44 to hour 98, exhaled mercury decreased for three youths (patients 5, 6, and 7), whereas readings for two youths (patients 3 and 9) indicated increases (Table 1). The increases, along with high concentrations in a motel room, suggested reexposure; investigation identified the source as a contaminated motor vehicle. Patient 7, who had a longer half-life of exposure than patients 5 or 6, was determined to have been reexposed by the same contaminated motor vehicle (Table 1). Comparison of mercury vapor concentrations near the skin and hair at hours 42–44 and 98 confirmed the reexposures observed in exhaled mercury (Table 1) and the motel room. Mercury vapor concentrations in motel rooms decreased after isolation of the contaminated motor vehicle and disposal of contaminated personal items. The last blood mercury analyses for all youths, except patients 12 and 13, indicated concentrations below laboratory reporting limits (4–5 μg/L), suggesting cessation of the exposure. No further treatment was indicated for any patient. The correlation

TABLE 1. Mercury vapor concentrations (ng/m^3)* associated with nine patients after mercury exposure — Dakota County, Minnesota, 2004

	Near hair				Near skin (chest)		Exhaled air		
Patient no.	Hour 24	Hour 42	Hour 43†	Hour 98	Hour 44	Hour 98	Hour 44	Hour 98	$t_{1/2}$§(hrs)
1	635¶	1,742		664¶			571		
2		376		142**	597	454**	990		
3		430		327**	546	1,662**	575	1,890**	††
4		381		38	128	48		66	
5		1,247		169		273	380	90	26
6	17,000¶	4,812	2,690	94	1,634	62	442	101	25
7		9,681	873	3,926**	1,384	1,163**	1,446	616**	44
9		283		106**	424	254**	239	379**	††
12	35,000¶		850¶						

* Sampling volume ~20 L/min; sampling rate: mean of 3 x 10 second averages, by using a real-time mercury vapor analyzer.
† After shampooing at hospital.
§ Exhalation half-life: calculated from two exhaled mercury vapor data points.
¶ Data likely a maximum, by using a real-time mercury vapor analyzer at a 1-second sampling rate.
** Patient determined to be reexposed.
†† Sampling data indicated increase.

TABLE 2. Total mercury in whole blood and urine* of 14 patients after exposure to mercury — Dakota County, Minnesota, 2004

Patient	μg mercury/L blood							μg mercury/g creatinine (mL urine)		
no.	Day 2	Day 4	Day 7	Day 9	Day 10	Day 11	Day 15	Day 5	Day 7	Day 10
1	9						<5	3 (850)		
2	9				<5			7 (300)		
3	13				<5					6 (750)
4	<5		<5							
5	<5		<5							
6	†								6[§]	
7	12				<5			5 (350)		
8				<5						
9	8			<5					<10[§]	
10						<5				
11	<4									
12	†				6				<10 (450) no date	
13		5								
14							<4			

* 24-hour urine sample requested.
† Sample coagulated, not analyzed.
§ Small sample volume; presumed random.

between blood mercury and exhaled mercury for individual youths was low (R^2 = 0.27).

Testing in eight of the youths' residences indicated maximum mercury vapor concentrations ranging from <60 ng/m^3 to >50,000 ng/m^3 (Table 3). Three additional homes were found to be contaminated by adults tracking mercury. Cleanup in accordance with MDH criteria and reoccupancy of all contaminated homes was completed 22 days after the initial incident. The Minnesota Pollution Control Agency used a mercury-sniffing dog (*1*) to find the source of contamination in the last house cleared. Tracked mercury was located by using a mercury vapor analyzer. Three of four contaminated cars could not be cleaned to the MDH criterion for clearance and were scrapped. All visible traces of mercury were cleaned from the basketball court and other affected outdoor areas. Dakota County Public Health nurses tracked all of the youths, facilitating medical examinations and testing and providing support for families.

Reported by: *BA Baker, MD, Regions Hospital Occupational Medicine Clinic, St. Paul; C Herbrandson, PhD, T Eshenaur, MPH, RB Messing, PhD, Minnesota Dept of Health.*

Editorial Note: Exposure to elemental mercury occurs largely from inhaling mercury vapors; very little mercury is absorbed through the skin or by ingestion. Mercury spills pose a serious health hazard and are difficult to clean because most common methods (e.g., sweeping or vacuuming) disperse mercury, increasing the surface area of the mercury, increasing evaporation, and exacerbating the contamination. This report illustrates that use of real-time portable instruments such as mercury vapor analyzers can enable investigators to rapidly measure mercury vapor concentrations and determine the extent of an exposure incident.

Geometric mean and 95% total blood mercury concentrations in the 1999–2002 National Health and Nutrition Examination Surveys (NHANES) for women of childbearing age were 0.92 μg/L and 6.04 μg/L, respectively, and for young children were 0.33 μg/L and 2.21 μg/L, respectively (*2*). Almost all inorganic mercury blood concentrations in the

TABLE 3. Maximum mercury vapor concentrations (ng/m^3)* in eight households of 13 patients exposed to mercury — Dakota County, Minnesota, 2004

Patient no.	Mercury vapor	Location	Time (hrs)	Mercury vapor	Location	Time (hrs)
1	1,500	At front door	24	2,270	Shower	48
2, 3, 7	17,000	Dresser drawer	98	1,900	Ambient air	98
4, 5	17,000	Outdoor steps	114	>50,000	Floor by couch	114
6	<200	Throughout home	98			
8	<60	Throughout home	9	1,300	Bag of clothes	9
9	735	Bedroom, ambient	114	3,412	Closet in bedroom	114
10, 12	3,600	Backpack	20	765	Bedroom	20
13	1,900	Ambient in house	9	7,500	Living room chair	Unknown
14	<200	Ambient in house	9			

* Using a real-time mercury vapor analyzer.

NHANES study were below the detection level of 0.4 μg/L (*2*). Geometric mean and 95% concentrations of urine mercury for women aged 16–49 years in the 1999–2000 NHANES data were 0.72 μg/L and 5.00 μg/L, respectively (*3*). Normal exhaled air mercury concentrations are typically <50 ng/m^3 for persons without dental amalgams (Minnesota Department of Health and Minnesota Pollution Control Agency, unpublished data, 2004).

The half-life of total mercury in blood for persons exposed to mercury vapor is 2–5 days, reflecting distribution to tissues and elimination through exhalation (*4,5*), which corresponds to the results in this report; blood mercury levels were below the detection limit 7–13 days after initial positive measurement. Exhaled mercury concentrations have been found to decrease, with half-lives of 13–25 hours (*6*) and 1.6–2.3 days (*7*). These half-lives also are consistent with the results in this report. However, exhalation half-lives longer than 30 hours might indicate continuing exposure or reexposure to mercury. The patient with the calculated half-life of 44 hours had been reexposed on day 4. Exhaled vapor concentrations can also depend on proper exhalation by patients. To compare data between patients, investigators should instruct all patients to exhale in the same manner; however, mercury vapor half-lives are repeated measures and will not be as sensitive to individual differences. The lack of correlation between exhaled mercury and blood mercury is likely caused by measurement of different forms of mercury (i.e., total mercury for blood and mercury vapor for exhaled) and the small range of exposures.

Approximately 70%–80% of inhaled mercury enters the blood before distribution to tissues; the rest is immediately exhaled. An estimated 7% of retained mercury is exhaled in the first 3 days after exposure (*8,9*). Approximately 9.2% and 2.4% is excreted in feces and urine, respectively, within 7 days (*4*). Conversely, mercury concentrations in blood can increase rapidly after an acute exposure to mercury, providing timely indication of exposure. In addition, the short half-life of mercury in blood can enable confirmation of the cessation of exposure. However, investigators should be aware of potential confounders to measurements of mercury concentrations (e.g., fish consumption, dental amalgams, medicinal use, and ritualistic use of mercury such as sprinkling on a floor for good luck) (*10*).

In this report, the experiences of responders and investigators also underscore several recommendations for demolition and waste-disposal companies and government agencies. These include 1) securing elemental mercury at demolition sites, 2) confirming mercury decontamination by sampling, 3) providing sensitive field instruments and appropriate training for tracking mercury contamination and exposure, and 4) incorporating quality-assurance controls into all data collection activities.

Acknowledgments

This report is based on information contributed by Regions Hospital/Health Partners, St. Paul; G Kalstabakken, D Kuhns, Rosemount Police Dept; P Adams, K Dickinson, B Schroeder, J Springsted, K Wick, Dakota County Public Health Dept; D Fier-Tucker, C Hubbard, S Lee, H Neve, Minnesota Pollution Control Agency; DBW Jones, Minnesota Dept of Health. Agency for Toxic Substances and Disease Registry.

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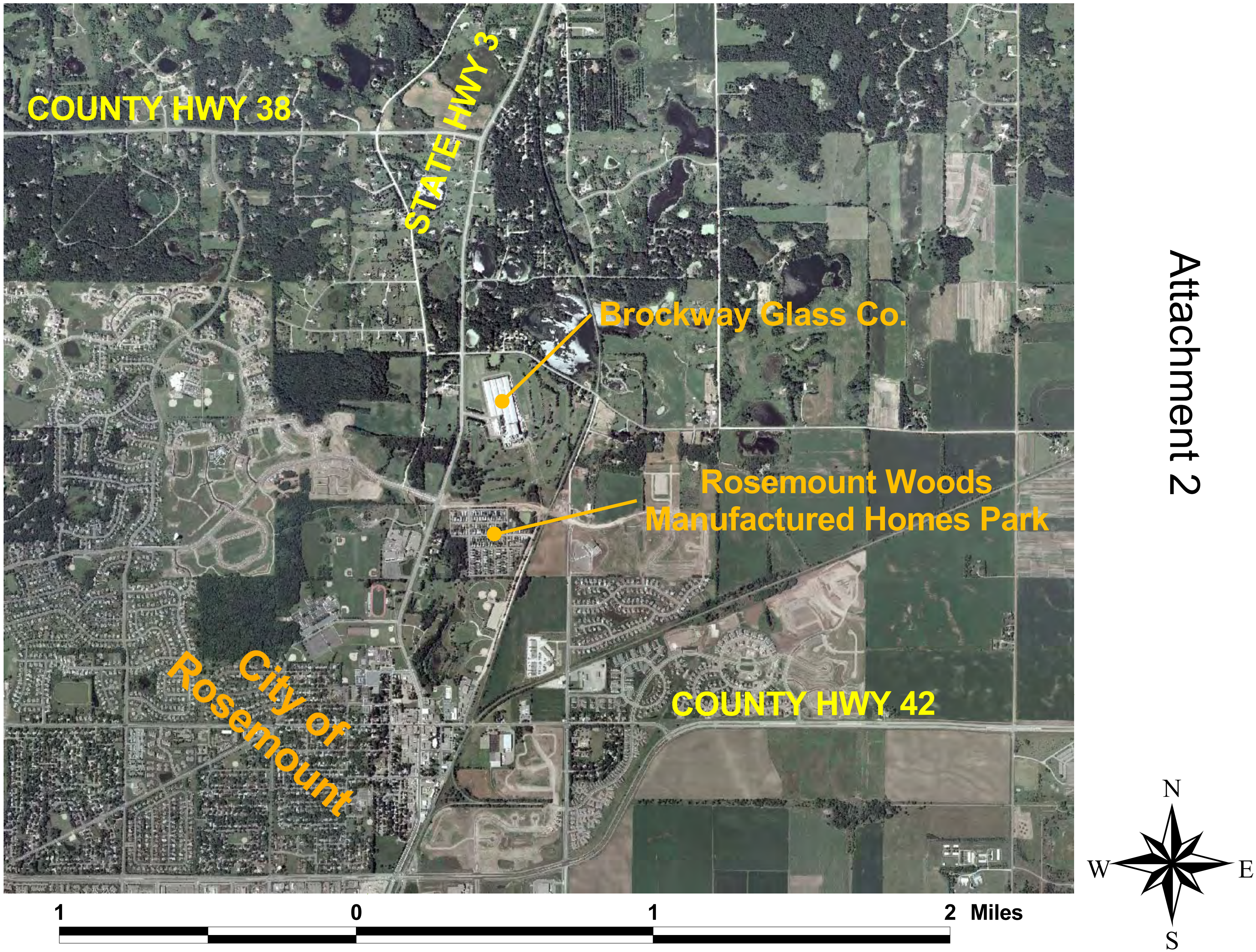
Site of Mercury Release, September 2004



Attachment 2

Attachment 3

Memo

Date: September 16, 2004

To: John Springsted
Public Health Department, Dakota County

From: Carl Herbrandson and Rita B. Messing
Site Assessment and Consultation Unit

Subject: **Clearance Criteria and Procedures for Re-Occupancy of Houses and Re-Use of Cars Contaminated with Elemental Mercury (Hg)**

Residences

Hg concentrations in ambient air in residences should be at or below 500 ng/cu.m. In order to ensure that this is the case the following protocol should be followed:

1) All air circulation in the house should be minimized for at least 30 minutes by closing windows, ducts and other outlets to outside air.
2) At least three 10 second average readings should be taken with a Lumex mercury vapor meter in each room of the house. Larger rooms may require more than three readings (e.g. one reading in the center of the room and one in each corner).
3) If any of the 10 second average readings are above 500 ng/cu.m the house should not be cleared for re-occupancy. The house may be re-occupied if all readings are below 500 ng/cu.m of mercury.

A house may be re-occupied for a short period of time (days) at concentrations up to 1,000 ng/cu.m. Further work will likely be needed to achieve the long term clearance value of 500 ng/cu.m in these cases.

Cars

Hg concentrations in ambient air in cars should be at or below 1,000 ng/cu.m.. In order to ensure that this is the case the following protocol should be followed:

1) All air circulation in the car should be minimized for at least 30 minutes by closing windows, vents and other outlets to outside air.
2) The car heater should be run for 20 minutes.
3) The car should be quickly re-entered, the doors closed, and the heater and engine shut off.
4) Three 10 second average readings should be taken with a Lumex mercury vapor meter. An average concentration should be determined from the 3 ten second readings (i.e., an average of the averages).
5) If the resulting average concentration from step 4) is above 1,000 ng/cu.m. of mercury the car should not be cleared for re-use. If the average reading is below 1,000 ng/cu.m. the car may be used.