Mercury Spills in Minnesota Schools: 1995-2007

Hazardous Substances Emergency Events Surveillance
Minnesota Department of Health

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Minnesota Hazardous Substances Emergency Events Surveillance

Summary
Despite increasing awareness about the environmental and health impacts of elemental mercury and coordinated efforts to remove mercury from schools, spills of mercury in schools continue to be reported in Minnesota each year (44 recorded by the Minnesota Hazardous Substances Emergency Events Surveillance (HSEES) system from 1995-2004 and 2006-2007). Sources of spills have included scientific or medical instruments, thermostats and similar gauges, storage vessels, and mercury brought into schools by students or staff. School administrators should be aware that mercury spills can occur and be prepared to respond. Most unheated mercury spills do not pose an imminent health threat but need to be isolated and cleaned up to prevent further dispersion and low level chronic exposure. To address concerns from students, parents or guardians, faculty, staff and others, administrators should be prepared to communicate information about mercury and the cleanup process. State and local health or environmental departments are often able to assist in communication efforts. In the long term, recent laws banning sale and distribution of many mercury-containing items should reduce the occurrence of mercury spills.

Introduction
Elemental mercury is a liquid at room temperature. Because it is a good conductor of electricity and it is sensitive to changes in temperature and air pressure, elemental mercury has been used in a variety of equipment, including thermometers, barometers, manometers, and switches (e.g., thermostats). These items have been commonly used in schools at the elementary, secondary and post-secondary levels.

Elemental mercury differs from the organic form of mercury called methylmercury. Methylmercury is formed when microorganisms convert elemental mercury in water bodies to this organic form of mercury. Human exposure to methylmercury mostly occurs from consuming fish or shellfish that have taken up and accumulated methylmercury in their tissues. Methylmercury in fish has prompted fish consumption advisories. This summary will focus only on elemental mercury releases.

Human exposures to elemental mercury are most often caused by spills from common devices, including thermostats, thermometers, barometers and blood pressure gauges, or occur in occupational settings where mercury is used. Most exposures to elemental mercury occur from inhalation of vapors, rather than from ingestion or dermal contact. When elemental mercury is ingested, very little is absorbed by the body, and most passes out unchanged. Similarly, very little elemental mercury passes through the skin.

Elemental mercury vaporizes at room temperature. The rate of vaporization increases when elemental mercury is heated. Vapor from elemental mercury is not visible to humans under normal light and does not have an odor, but is toxic when inhaled. Symptoms resulting from acute elemental mercury vapor exposure can include respiratory, cardiovascular, gastrointestinal, dermal and ocular effects (Agency for Toxic

Substances and Disease Registry [ATSDR] 1999, Counter 2003). Long-term exposure to elemental mercury vapor can affect the nervous system, kidneys, and liver, but has not been found to be related to cancer (ATSDR 1999). A condition called acrodynia, which usually involves a red, painful or itchy rash, peeling skin, elevated blood pressure and other symptoms, has been found in children that are exposed chronically to elemental mercury vapors (Beck, Krafchik, Traubici, and Jacobson, 2004; Tominak 2002).

The severity of health effects, both acute and chronic, is related to the dose, or the air concentration of the vapor inhaled and the time over which the exposure occurs. Children have a breathing zone that is closer to areas where spills settle, such as floors and counter tops, and might therefore receive larger doses than adults (Counter 2003, Risher and De Rosa 2007). In addition, developing fetuses, infants and children are more sensitive to mercury exposure (ATSDR 1999).

In recent years, mercury spills in communities and schools have received substantial media attention, which may have increased public awareness about mercury. The following report will describe the trends in mercury spills and responses in schools over time as recorded by the Minnesota Hazardous Substances Emergency Events Surveillance (HSEES) program. The report will also discuss efforts to reduce mercury in schools.

Methods

The Minnesota Department of Health has participated in the HSEES system since 1995. This program, sponsored by the Agency for Toxic Substances and Disease Registry (ATSDR) collects information about unplanned and illegal hazardous substances releases in participating states. The following states have participated in the HSEES system from 1995-2007: Colorado, Iowa, Minnesota, Mississippi, New York, North Carolina, Oregon, Texas, Washington, and Wisconsin. Seven states participated for part of this period: Alabama (1995-2005), Louisiana (2001-2007), Missouri (1995-2007), New Hampshire (1995-1996), New Jersey (2000-2007), Rhode Island (1995-2001), Utah (2000-2007).

Minnesota HSEES collects data from several sources, including the Minnesota Duty Officer (MDO), the U.S. Coast Guard National Response Center, the U.S. Department of Transportation Hazardous Materials Incident Reporting System, media reports, companies, and citizens. An HSEES event is defined as an uncontrolled, illegal or potential acute release of a substance that could result in an adverse human health effect. A potential release, also called a threatened release, is included if the threat prompted a public health action such as an evacuation or shelter-in-place order. Substances released are included at quantities of 10 lbs or 1 gallon or greater, unless the substance has been named to be included in the system at any quantity.

Because spills of mercury are often very small, spills smaller than 10 lbs or one gallon were included in 1995-2004 and 2006-2007. In 2005, mercury spills were not included in HSEES as the case definition was revised. A count of 2005 mercury spills in Minnesota was maintained separately from the HSEES system, though complete information

collected for HSEES was not obtained for these spills. Unless noted, statistics in this report include years 1995-2004 and 2006-2007.

Results

Number of spills

From 1995-2004 and 2006-2007 there were 4,705 events recorded in the HSEES system, including 111 releases of various substances (2.4%) in school settings. Excluding releases involving fluorescent bulbs only, 243 (5.2%) of the total were mercury releases with 44 (18.1%) mercury releases in schools (Figure 1).

Time of day

The majority of mercury spills in schools were reported between 6:00 a.m. and 5:59 p.m. (42 [95.5%]), with 21 (47.7%) events reported from 6:00 a.m. to 11:59 a.m. and 21 (47.7%) reported from 12:00 p.m. to 5:59 p.m. Only two releases (4.5%) were reported for 6:00 p.m. to 11:59 p.m.

Day of week

Most spills at schools occurred during weekdays (42 [95.5%]), but not all spills occurred when school was in session. Days with the most reported spills were Tuesday (13 [29.5%]) and Thursday (11 [26.2%]) and the fewest were reported on Saturday (1 [2.3%]) and Sunday (1 [2.3%]).

Month

The most spills occurred in the second half of the calendar year, with 28 events (63.6%) occurring from July to December. October (6 [13.6%]) and December (6 [13.6%]) had the most reported spills, while January had the least (1 [2.3%]).

Cause of release

The primary factor in most (33 [75.0%]) of the releases in schools was human error (e.g., dropping a thermometer), followed by equipment failure (6 [8.0%]) (e.g., broken blood pressure gauges). Intentional releases, such as dumping mercury from vials, were reported as the cause of the release for two events (4.5%). The cause of one (2.3%) event was reported as a “factor beyond human control”. The cause of release was not specified for two events (4.5%) (Table 1).

Source of mercury

The most common release source of mercury in schools was thermometers (17 [38.6%]), followed by barometers and manometers (5 [11.4%]) and sphygmomanometers (blood pressure gauges) (4 [(9.1%]). A vial or container of mercury was reported spilled in three school events (6.8%). A thermostat, a boiler component, and a sound chamber were each reportedly spilled once (2.3%). There were 12 events (27.3%) involving mercury discovered spilled from an unknown or unspecified source, such as mercury found in sink traps, lab cabinets, beneath lab fixtures or unnamed equipment (Table 2).

Quantity
Obtaining accurate estimates for quantities of mercury spilled during releases is challenging. Often the amount of mercury spilled from a piece of equipment is difficult to estimate, especially because mercury tends to form beads and scatter or become lodged in crevices. Because all contaminated items, wipes and other cleanup materials are disposed together, manifests usually document total weight or volume of materials removed, rather than mercury alone.

Reported quantities of mercury spilled ranged from less than 1 g to more than 3128 g, though many quantities were reported as a range. Using both actual quantities reported and the midpoint of reported ranges, the mean quantity reported spilled was 322 g (median 27.2g).

In general, there are about 0.5 g to 3 g of mercury in thermometers and about 100 g of mercury in sphygmomanometers (blood pressure gauges). The amounts of mercury in barometers and manometers vary, depending on the use of the instrument. Amounts of mercury in switches also vary by type. Mercury stored in vials or jars sometimes total several kilograms (elemental mercury weighs 13.6 kg/L).

Evacuations
There were 17 (38.6%) mercury spills in schools that involved evacuation. Exact or estimated number of people evacuated was reported for 16 events, totaling about 1,720 evacuees. The mean number of people evacuated per event was 108 people (median = 25), with a range of 3 to 550. The mean time of the evacuation was 63 hours (median = 27 hours) with a range of 48 minutes to 336 hours. Events with evacuations were in classrooms, laboratories, hallways, dorm rooms, a school bus and other occupied areas.

There were 26 events that did not involve an evacuation. Non-evacuated areas included classrooms, laboratories, or hallways and loading docks. Often evacuation did not occur when the school was not in session or when the spill was in an area not usually accessible to students, such as boiler rooms, loading docks and storage rooms.

Responders
Specific information about responders to mercury spills was not collected for 1995-2001. However, detailed information about on-scene responders was collected from 2002-2004 and 2006-2007 (Table 3). Overall, many responses involved a school response team or a hazardous materials contractor. Responders also sometime included public health or environmental agency staff, such as the Minnesota Pollution Control Agency (MPCA) emergency response team. In recent years, police or fire departments appear to have been summoned more frequently to mercury spill incidents.

Discussion
The majority of mercury spills in schools were reported in the past 6 years, though it is unknown if this represents an actual increase in the number of spills. This increase could indicate greater awareness about mercury and better reporting of spills.

Educational efforts by environmental and public health agencies in recent years have brought more attention to mercury issues. Proper disposal and safe handling of elemental mercury have been emphasized through various public awareness campaigns. For example, the Mercury Free Zone Program at the MPCA has been working in schools to educate about mercury and encourage proper disposal since 2001 (Minnesota Pollution Control Agency [MPCA] 2006b). As of July 2008, the program has collected over 3,370 pounds of mercury from schools (MPCA, personal communication, July 29, 2008). In addition, many counties have been making efforts to raise awareness about household hazardous wastes, including mercury, and encouraging proper disposal at household hazardous waste facilities. Further, the Minnesota Legislature passed several laws in recent years restricting or banning the sale, use, or distribution of several types of mercury-containing items in the state, including manometers, thermometers, sphygmomanometers, gastrointestinal devices, thermostats, switches and relays, diostats and barometers, and pyrometers (Minnesota Statutes, 2007a).

Despite these efforts, mercury is still fairly ubiquitous. Even in schools that have made mercury clean out attempts, mercury sometimes remains in equipment or storage vessels that were not discovered, in drain traps, or in equipment still in service, such as thermostats or sphygmomanometers. Mercury-containing items are also sometimes brought into a school by students, staff, or visitors. All of these sources can result in unexpected mercury releases within a school.

Mercury spills can present at least four interrelated issues for schools: 1) protection of physical and mental health; 2) disruption of the learning environment; 3) communication issues with students, parents or guardians, and the community; and 4) cleanup costs. School officials need to be aware of these issues and prepared to address them if a spill occurs.

First, protection of health during a mercury spill is important, though often the threat to health is not imminent. Health concerns generally arise if exposure to vapors continues for lengthy periods. Inhalation of vapor is the primary route of mercury exposure from a elemental mercury spill (ATSDR 1999). A small spill (<1 g) of mercury, such as one from a thermometer, is not necessarily threatening to health unless the mercury is in a location where its vapor will be inhaled repeatedly by individuals, especially pregnant women or young children, over a long period of time or the mercury has been heated.

Response to mercury spills in schools usually involves isolation of the area and preventing people entering and leaving the site of the spill from tracking the mercury. Ensuring that sources of possible continued mercury exposure have been removed is the primary objective. Repeated exposure to mercury can occur when it has contaminated items or areas that are frequently used (Beck, Krafchik, Traubici, and Jacobson, 2004; Risher, Nickle, and Amler, 2003), such as pillows, bedding, clothing, jewelry, toys, keys, cell phones, or carpeting in locations where children might repeatedly sit, play, lie or sleep. Response for most spills therefore involves evacuation or restriction from the affected area; shutting down ventilation systems; screening of items and people near the spill for contamination; cleaning or disposal of contaminated items; and cleaning and

ventilating the contaminated area. Detailed advice for mercury cleanup in Minnesota is available from the Minnesota Pollution Control Agency (MPCA 2006a).

If mercury is heated, the mercury vaporizes more quickly and air concentrations of mercury could rapidly rise to levels that can result in serious, possibly fatal, health effects (ATSDR 1999). Even small amounts of heated mercury spills have had devastating results (ATSDR 1999, Bauman 2006, Brubacher 2002, Counter 2003, Jaeger, et. al., 1979). If mercury spilled in a school has been heated in any way, immediate evacuation and restriction from entry to the area is necessary. Advice from trained personnel on cleanup should be requested (MPCA 2006a).

While not every spill results in a full school emergency, most spills create some disruption to the learning environment. Students must often be moved from their usual learning area and can be distracted by the cleanup process. If plans for chemical spills or similar emergencies are in place and understood by teachers and administrators, disruptions from mercury spills may be minimized and the learning environment restored quickly.

In addition, communication not only with students, but with school employees, parents or guardians and the community is important (U.S. Department of Education [ED] 2007). Most mercury spills do not pose a health threat if the mercury is contained and cleaned up promptly. To quell concern and maintain trust, accurate information about mercury and the specific incident should be communicated as appropriate. Direct communication with the media is important if the incident is being covered in the news (ED 2007). Local or state health or environmental agencies are often able assist with communication efforts. Some agencies also have standard information sheets available.

Another issue related to mercury spills is the cost of cleanup. Although the amount of mercury spilled is usually a few milliliters in volume, the clean-up costs are often thousands of dollars. A particularly expensive cleanup of a mercury spill in a Minnesota school in 2006 required a special budgetary appropriation by the 2007 State Legislature to pay for the cleanup (Laws of Minnesota 2007). In another example reported by the Environmental Protection Agency, a cleanup of mercury pilfered from a school cost nearly $1.5M (EPA 2007). When possible, prevention of dispersion of spilled mercury can help to reduce cleanup costs by reducing the areas requiring cleanup and testing.

The monetary cost of a mercury spill can extend beyond the cost for cleanup, however. For large spills, the local emergency responders, such as police and fire department are sometimes called to the site for assistance, burdening community resources. In some incidents, school buildings or even entire districts have been closed while the cleanup is complete. Transportation involved in relocating staff and students further increases cost. In addition to monetary costs, disrupted schedules for children, families, school employees, and community members utilizing school facilities for activities represent an additional cost related to the spill.

In attempt to reduce future mercury spills in schools, the 2007 Minnesota State Legislature passed a law requiring schools to stop purchase and use of elemental mercury and mercury-containing items, such as thermometers, after December 31, 2007. After December 31, 2009, schools cannot store elemental mercury for any purpose, excluding thermostats for heating, ventilation, or air conditioning in the school (Minnesota Statues, 2007b). This Minnesota legislation is similar to laws passed by other states in similar attempts to reduce mercury spills in schools (EPA 2007).

While this legislation might aid in reducing mercury spills, schools will need to remain watchful for unexpected sources of mercury spills. For example, thermostats, which often contain mercury switches, have been involved in mercury releases documented in the HSEES system. These devices, which might remain in schools after other sources of mercury have been removed, should be protected from breakage. In addition, mercury releases have occurred in schools from items brought onto school property by students or staff. Schools should develop and promote education about hazardous chemicals and the dangers of bringing them to schools.

As the mercury legislation becomes effective and schools become more aware of mercury issues, mercury incidents should decline. Data from the HSEES program will aid in monitoring any changes in mercury spill trends.

Limitations

While efforts are made by the HSEES program to collect information about all qualifying hazardous substances releases, not all spills are reported to sources accessible to HSEES. Thus, the number of mercury spills in schools could be underrepresented in this report. In addition, changing case definitions for the HSEES system affected data collection at times, (e.g., omission of most mercury spills in 2005).

Conclusion

The HSEES program has been useful in showing trends of reported mercury spills in schools, particularly the increase in the number reported in recent years. As the HSEES program continues to collect data on hazardous substances releases, it will monitor whether the number of mercury releases changes over time. This monitoring will help to determine the effect of Minnesota legislation on the frequency of spills in schools in the state. Moreover, data from other HSEES states with similar legislation will help to further evaluate legislative impacts. Even if a decline in mercury releases occurs, continued education about mercury and appropriate response to spills will be necessary, as well as promoting mercury-free alternatives when possible.

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Table 1. Causes of mercury spills in Minnesota schools, 1995-2004, 2006-2007
Minnesota Hazardous Substance Emergency Events Surveillance

Primary Factor	Number of events	Percent %
Human Error	33	75.0
Equipment failure	6	13.6
Intentional	2	4.5
Factor beyond human control	1	2.3
Unspecified	2	4.5
Total	**44**	**99.9**

* Total not equal to 100.0% due to rounding.

Table 2. Sources of mercury spills in Minnesota schools, 1995-2004, 2006-2007
Minnesota Hazardous Substance Emergency Events Surveillance

Elemental Mercury Source	Number of events	Percent %
Thermometers	17	38.6
Unknown/unspecified	12	27.3
Barometers or manometers	5	11.4
Sphygmomanometers	4	9.1
Vial or container	3	6.8
Sound chamber	1	2.3
Boiler component	1	2.3
Thermostat	1	2.3
Total	**44**	**100.1**

* Total not equal to 100.0% due to rounding.

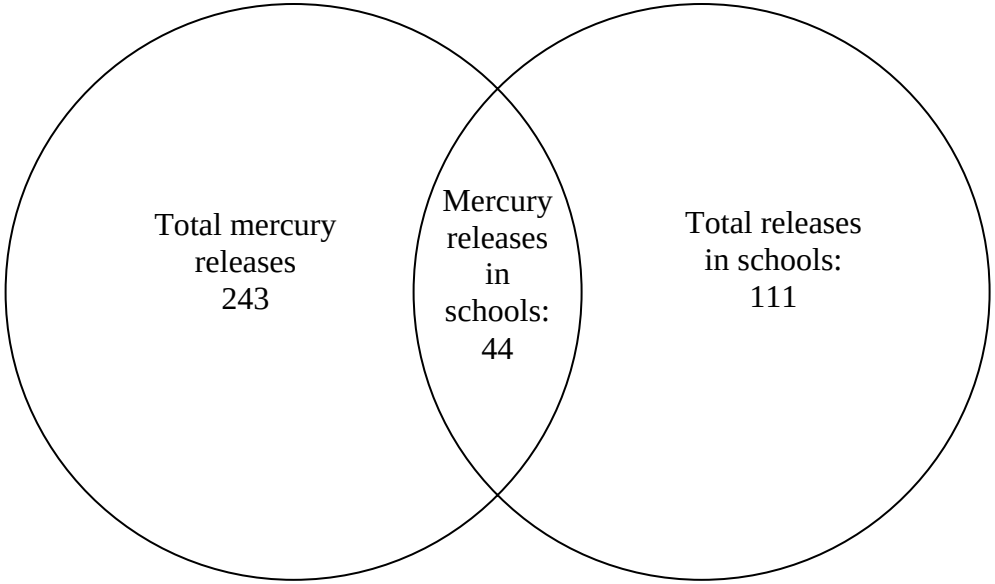
Table 3. Responders to school mercury spills, 1995-2007
Minnesota Hazardous Substances Emergency Events Surveillance

Responder	Number of events	% of events with this responder
Certified Hazardous Materials Response Team*	3	6.4
Environmental Department	8	17.0
Fire department	1	2.1
Hazardous Materials Clean up Contractor	10	21.3
Health Department	2	4.3
Police Department	1	2.1
School staff	22	46.8
Total**	**47**	**100**

*Emergency responders, often part of a fire department, with special training in chemical spill response.

**There could be more than one responder per event.

Figure 1. Comparison of mercury spills and releases in schools: 1995-2004, 2006-2007
Minnesota Hazardous Substances Emergency Events Surveillance



4,705 total events (1995-2004, 2006-2007)