Preventable Poisons
A Prescription for Reducing Medical Waste Pollution In Maryland

MaryPIRG and the Maryland Public Interest Research Foundation
Preventable Poisons:
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A Report by
Maryland Public Interest Research Group
and Maryland Public Interest Research Foundation

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Executive Summary

Preventable Poisons:
A Prescription for Reducing Medical Waste in Maryland

This report brings together for the first time information about the environmental and public health hazards of medical waste incinerators, an assessment of medical waste incineration in Maryland, and methods for reducing the volume and toxicity of products used and disposed of in hospitals. As new regulations for medical waste incinerators loom, healthcare facilities are seemingly presented with relatively minor variations on waste disposal options: burn or bury their waste. This report presents the case that the optimal economic and environmental choice is a materials use policy centered around reduce, reuse, and recycle strategies.

Major findings of the report include:

1) **There are 41 medical waste incinerators (MWIs) in Maryland.**

2) **Thirty-one of these (75%) do not have air pollution control devices.** MWIs that do employ pollution control are largely equipped with devices designed to capture particulates and acid gases, not dioxin and mercury, toxins of critical public health concern.

3) **Only two medical waste incinerators regularly test for toxic emissions.** Although MWIs are inspected once a year by the Maryland Department of the Environment (MDE), inspection merely includes looking at the unit, recording the operating temperature and the amount of material charged in the unit, and checking for visible emissions. Inspection does not include a stack test to measure pollution output. In fact, no MWIs in the entire state of Maryland have ever undergone stack tests with the exception of three incinerators, all of which have some pollution controls.

4) **Maryland MWIs burn over 42,000 tons of mixed medical waste and pathological medical waste annually -- 16% above the national per capita average.** Compared to other commercial or household trash, healthcare facility waste contains a much higher percentage of polyvinyl chloride (PVC), a plastic which produces dioxin when burned.

5) **MWIs are major sources of dioxin, mercury, and other dangerous toxins.** The U.S. Environmental Protection Agency (EPA) estimates that MWIs are the second or third...
leading source of dioxin in the environment. Tests conducted in 1996 at Phoenix Services MWI determined that average dioxin emissions were over 5 times MDE's proposed standard for existing MWIs. Because the Phoenix Services MWI operates continuously, other smaller, intermittent MWIs may well release even more pollutants. According to MDE data estimating uncontrolled emissions, Maryland MWIs also may emit each day approximately 13.5 pounds mercury, 9.7 pounds of lead, 40.5 pounds of cadmium, and 4,527.8 pounds of hydrogen chloride according to MDE estimates. Taking current controls into account, MWIs release 968 pounds of mercury each year. Other MWI emissions include particulates, carbon monoxide, sulfur dioxide, and nitrogen oxides.

6) **Children, minorities, and the poor are the victims of this pollution.** While only 18% of white people live near a MWI, 34% percent of Maryland’s minority population, 43% of people in poverty, and 240,633 children live within 2 miles of a medical waste incinerator, according to a 1996 Environmental Working Group report.

7) **The proposed MDE regulations for MWIs fail to protect public health.** The draft regulations do not contain any requirements for pollution prevention, such as waste reduction and recycling, or set emission standards for a number of important pollutants, including arsenic, chromium, nickel, and PCBs. The proposed standards would allow 19 times more dioxin emissions than standards in some European counties, and nearly 4 times as much mercury as allowed in Florida or New York.

8) **Fifteen percent or less of a typical hospital’s waste stream needs to be treated as infectious and sterilized** according to the EPA. Hospitals routinely burn 75-100% of their waste.

9) **Hospitals and other healthcare facilities can effectively prevent waste and pollution through "reduce, reuse, recycle" initiatives.** As shown by hospitals across the United States, these initiatives can save money, while protecting public health and the environment. They include finding substitutes for products made from hazardous materials, such as PVC and mercury, switching to reusable products, and recycling paper, metals, plastics, and other materials.

**Guiding Principles**

Our major findings alone indicate the need for healthcare facilities to take action to reduce the toxicity and volume of their waste stream. In addition, there are three principles which guide our recommendations:

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1 In 1999, Phoenix Services added new pollution controls which reduced the amount of dioxin emitted. Because Phoenix Services is one of a minority of operators in Maryland with such controls, the 1996 test results are more representative of the entire MWI picture.
1) The first principle is that it is better to prevent pollution and waste than to try to capture, clean up, and treat it after it's been produced. This principle is grounded in the experience of communities throughout the state who bear the burden of the latter approach -- people living next to waste facilities, such as incinerators and landfills. Pollution and waste prevention require a shift from a narrow focus on "waste management" to "materials management": assessing -- and reducing -- the lifetime of impacts from producing, using, and disposing of a product.

2) The precautionary principle can be understood as the "better safe than sorry" approach. It shifts the burden of proof. Currently, communities and environmental agencies are required to develop absolute proof that industrial practices are harmful before taking action. Under the precautionary principle, the onus is on private interests to prove that their practices are not harmful to the public. This principle has numerous practical applications. For example, even though uncertainty remains about precisely how much dioxin is emitted by MWIs, the precautionary principle requires that, given what we know about its extreme toxicity, measures should be taken to reduce MWI dioxin emissions.

3) "Do no harm" is the first guiding principle of physicians. With its elegant simplicity and moral power, "do no harm" should be applied to healthcare institutions in their totality. An honest and thorough application of this principle requires examining the wider implications of healthcare practices -- considering not just patient care, but the health of the community surrounding the hospital and even the planet.

The Problem: Dioxin, Mercury, and More
The incineration of regulated medical and general hospital waste results in air and water emissions of dioxin, mercury, other toxic heavy metals, particulates, and sulfur dioxide. Even earlier in the "product life cycle," the manufacturing, transportation, and use of hospital products results in the consumption of energy, toxic feed stocks, and natural resources, contributing to environmental degradation and pollution. While a full discussion of these life cycle impacts is beyond the scope of this report, an awareness that they exist is essential.

Maryland healthcare facilities produce 35,219 tons of mixed medical waste and 5,973 tons of pathological medical waste annually, according to MDE and EPA estimates. Maryland MWIs import another 877 tons of medical waste per year, totaling 42,069 tons of medical waste burned in Maryland per year. Over 84% of this waste, or 35,480 tons, is burned in Baltimore City alone. This waste includes a number of materials and items which contribute to toxic air emissions: mercury-containing thermometers and lighting tubes, "red bags" colored with pigments containing lead, and products and packaging made from polyvinyl chloride (PVC), a plastic which contributes to the formation of dioxin.

The EPA's draft dioxin reassessment listed MWIs as the largest known source of dioxin. Since its publication in 1994, the EPA has revised this estimate, but MWIs still rank as one of the largest sources of dioxin. "Dioxin" is actually a family of chemicals with three properties which make it extremely dangerous. First, dioxin is extremely persistent, meaning that it degrades very slowly in
the environment. Second, dioxin bioaccumulates in fat tissue, so that it travels up the food chain in increasingly greater quantities; thus, grazing cattle concentrate the dioxin which contaminates their food, leading to much larger amounts of dioxin in beef and milk. Third, dioxin has a broad range of health impacts: it has been linked to reproductive and developmental disorders, immune system damage, endocrine disruption, and cancer.

According to MDE estimates of uncontrolled emissions, Maryland MWIs may release 447,000,000 micrograms of dioxin each day. Dioxin causes cancer in lab animals in doses as low as 1.4 thousandths of a microgram. Other adverse health effects include reproductive disorders, birth defects, and immune system damage. EPA reports that dioxin loads in humans are currently at the point that they would cause adverse effects in animals.

The Maryland Department of the Environment (MDE) estimates that MWIs release 968 pounds of mercury each year. Mercury is highly toxic in trace amounts: a drop of mercury as small as 1/70th of a teaspoon can contaminate a 25-acre lake to the point that the fish in it are unsafe to eat. This mercury travels long distances before settling onto soil or water, where it is transformed by bacteria into methylmercury, its most dangerous form. Like dioxin, methylmercury travels up the food chain, accumulating in fish and wildlife. Human exposure to mercury, usually from eating contaminated fish, can result in developmental and neurological problems.

**Solutions: Preventing Pollution and Waste by Reducing, Reusing, and Recycling**

Effective waste and pollution prevention can be accomplished by instituting aggressive "reduce, reuse, recycle" measures. These measures often save money for hospitals, by reducing purchasing and disposal costs, and through the sale of recyclable materials.

As opposed to a "waste management" approach, the "Three R" model focuses on healthcare materials use. The first two strategies -- "reduce" and "reuse" -- involve opportunities to prevent pollution and waste in the purchasing of products. Reduction strategies include eliminating unnecessary packaging, avoiding unneeded product use, and reducing the purchase of products containing toxic materials, such as PVC and mercury. Reusable products should also be purchased, where available.

An effective recycling program necessitates reducing the unnecessary "red-bagging" of non-infectious waste. This not only saves money, but increases the amount of materials available to be recycled. Much hospital trash is similar to household trash, and can be recycled --- from newspaper to metal cans to batteries.

**Institutional and Policy Recommendations**
The general goals of our policy recommendations are:

1) Reduce the volume and toxicity of the healthcare facility waste stream through adoption of...
the "reduce, reuse, recycle" model.

2) Eliminate the nonessential incineration of medical waste.
3) Set and enforce strict health-based standards for emissions from medical waste incinerators.
4) Encourage the examination of alternatives to incineration, such as autoclaving and microwaving.

Our policy recommendations are directed at three audiences: individual healthcare facilities, accreditation organizations, and the Maryland Department of the Environment. More detailed recommendations are contained in the Policy Recommendations chapter.

Recommendations:

1. Healthcare Facilities

   • Conduct comprehensive waste audits to determine where waste is being generated, what types, how it is being disposed of, and at what cost.
   • Examine purchasing practices to reduce unnecessary packaging, identify products containing PVC and mercury, and determine if substitutes are available.
   • Examine hospital operations to determine where and how disposable products can be substituted with reusable versions.
   • Institute waste segregation programs to reduce "red bag" waste and increase recycling.
   • Investigate alternative technologies, such as autoclaving and microwaving.

2. Accreditation Organizations

   • All accreditation organizations should require healthcare facilities to implement materials use policies designed to reduce the volume and toxicity of the medical waste stream.

3. Maryland Department of the Environment

The Maryland Department of the Environment’s proposed regulations for medical waste incinerators should be strengthened to further minimize the health threat posed by MWI emissions in the following ways:

   A) Set stronger emission limits

      • Require the maximum achievable control technology (MACT) as required by the Clean Air Act.
      • Include limits for arsenic, chromium, nickel, and PCBs.
      • Hold small rural incinerators to the same emissions standards as other incinerators.
      • Require all incinerators to implement the new standards by March, 2001.

   B) Require waste segregation

      • Require operators to develop plans which contain detailed strategies for reducing the volume and toxicity of the waste stream.
      • Mandate the implementation of waste management plans.
• Provide guidance on alternative approaches to meeting emission limits, such as waste segregation for mercury-containing and PVC materials in MDE's Technical Support Document for Hospital Medical Infectious Waste Incinerators.
• Include waste prevention as a component of incinerator operator training.
• Require operators of commercial MWIs to hold waste prevention trainings for clients.

C) Strengthen testing and inspection
• Require continuous emissions monitoring for carbon dioxide, hydrogen chloride, sulphur dioxide, nitrogen oxide and oxygen.
• Take into account the frequency of startups and shutdowns when permitting and monitoring incinerators.
• Prohibit the averaging of test runs -- one failure should constitute failing the test.
• Publish stack test results in the newspapers of the communities who host the MWIs.

In addition, MDE's Office of Technical Assistance should conduct research and provide technical assistance to healthcare facilities to help them reduce the volume and toxicity of their waste streams.
Introduction

Hospital Product Use and Disposal as a Public Health Issue

The professional staff, support services, and advanced technology of healthcare facilities are intended to promote good health. Yet many medical products and materials pose occupational and public health threats during their life cycle of production, use, and disposal. Intravenous solution bags, tubing, various medical devices, thermometers, solvents, laboratory supplies, and fluorescent lights are made of or contain substances which are harmful to human health and the environment. Even paper, when bleached with a chlorine-based process, leaves a legacy of dioxin to soil, sediments and the food chain.

The amount of hospital waste generated in the United States is about 2.4 million tons annually--approximately 1 percent of the municipal waste stream. This estimate does not include physician, dental, and veterinarian offices, nursing homes, outpatient facilities, and blood banks. Hospital waste composition varies considerably from other municipal waste primarily because of the much larger concentration of plastics. Plastics comprise roughly 15-30 percent of the medical waste stream--twice that of ordinary municipal waste. Among the list of plastics is polyvinyl chloride (PVC), widely used in many products and approximately 50 percent chlorine by weight. Paper and cardboard (45 percent), food waste (10 percent), glass (7 percent), wood (3 percent), metals (10 percent), and other materials (10 percent) make up the rest.

The term "medical waste" is often used to refer to that portion of hospital waste generated as the result of patient diagnosis, treatment, or immunization. It is a small portion of general hospital waste, much of which comes from hospital activities far removed from patient contact. Even smaller is the portion which is considered "infectious waste"--that which could transmit an infectious disease. Individual states have established a remarkable variety of definitions of medical facility waste which is subject to regulation--"regulated medical waste"--often causing confusion when comparing one state with another.

Public attention and the regulatory response to medical waste usually focuses on waste disposal rather than its prevention. The improper disposal of medical waste captured widespread attention in the summer of 1988. When used syringes and blood vials washed up under vacationers' feet on beaches from the Northeast to the Gulf of Mexico, there was public outcry. Concern about exposure to serious infectious diseases, such as AIDS or hepatitis, heightened the sense of alarm.

Congress responded by enacting the Medical Waste Tracking Act, affecting New York, New Jersey, Connecticut, and Rhode Island. The law established a two-year demonstration program to track medical waste from its point of generation to its final treatment or disposal. It provided no
finding, personnel, or guidelines for safe treatment of regulated waste. Though the law expired in 1991, it focused attention on waste disposal rather than waste reduction. Medical waste incinerators (MWIs) were temporarily exempted from Environmental Protection Agency (EPA) regulation under the Clean Air Act. “Burn it and get rid of it” became the operative policy. In part, this was the result of concerns about infectiveness of waste transported off-site. All of this is reflected in the floor regulations the EPA passed in 1997 and in the correlating Maryland Department of the Environment (MDE) proposed regulations. The regulations focus on controlling stack emissions without looking at pollution prevention through waste reduction, materials reuse, and recycling initiatives.

Community activists have long been concerned about inadequately regulated and monitored on-site hospital and commercial incinerators. Though originally intended to burn pathological waste (human or animal parts), many are used for disposal of a diverse menu of general hospital trash. Incinerators are a source of hazardous air emissions and toxic ash relegated to landfills. They are a major source of dioxin and mercury. Other hazards include lead and chromium as well as particulate and sulfur dioxide air pollution. The toxic exposures and releases which occur during the production and disposal of products are another concern. For example, dioxin is also produced during the manufacture of chlorine and plastics containing polyvinyl chloride. Workers and nearby community members are at risk during this phase of the life cycle.

**Dioxin: Diverse Toxicity and Widespread Exposure**

Dioxin is a term applied to what is actually a family of largely man-made related chlorinated chemicals with a variety of forms of toxicity. Dioxin is a by-product of certain industrial processes including incineration, pulp and paper bleaching, and chemical manufacturing. It does not easily degrade, tends to persist in the environment, and accumulates in the fat tissue of exposed organisms.

The EPA's ongoing reassessment of dioxin is one of the most extensive efforts ever undertaken to examine the toxicology of a chemical. The 1994 draft document extends to nine volumes, bringing together the work of hundreds of scientists and peer-reviewed papers, systematically summarizing a vast body of research including the molecular biology of dioxin, results of animal and epidemiological studies, sources, and human exposure levels. The variety of health effects resulting from exposure is reviewed in detail with careful attention to informational gaps and areas of uncertainty.

Dioxin influences fundamental cellular processes through interaction with receptors, genes, and various proteins. It causes cancer in virtually all species of experimental animals tested. Several epidemiological studies in humans, whose exposures were higher than those likely from the general environment, show an increased incidence of cancer as well. Dioxin, an endocrine disrupter, also causes reproductive and developmental abnormalities and immune system toxicity.

Though discontinued in 1990, the EPA's National Human Adipose Tissue Survey, in which fat
tissue samples were gathered periodically from around the United States, showed that all Americans have a body burden of dioxin. Perhaps more importantly, the survey also showed that levels of dioxin-like compounds in human tissues were sufficiently high to be associated with adverse health effects. Even if all worldwide dioxin generation were to cease immediately, with a half-life in fat tissue of approximately 5-10 years, human dioxin levels would decrease slowly.

In 1994, the EPA reported that, collectively, MWIs were the largest known single source of dioxin in the United States. The original calculation was based on sampling from only a few MWIs with the results extended to the agency's best estimate of the total number of facilities in operation. Since then the EPA has revised its emissions estimate downward because of closure of many small incinerators lacking air pollution controls, the addition of air pollution controls to others, and more sampling. Nevertheless, even the more recent estimate continues to rank MWIs second or third among the sources of dioxin emissions. Moreover, unregulated medical waste, which is disposed of in other municipal waste incinerators, also contributes to dioxin emissions.

A Limited Perspective
The historic mission of hospitals has been the acute care of identified illness. Physicians, nurses, and other healthcare professionals, focusing on the best interest of individual patients, may not be aware that some of their practices have a negative impact on community health and the environment. Most have not highly prioritized pollution prevention or waste reduction as means to contribute to long-term community health. Cost, convenience, and patient outcome regularly influence product purchase, use, and disposal decisions. Public health and environmental impacts are rarely discussed. Moreover, today's emphasis on institutional mergers, managed care, efficiency, and cost-cutting has further burdened healthcare professionals, leaving little time or energy to deal with longer-term environmental health issues.

Developing Coalitions for Change
When the EPA reported MWIs as the largest known source of dioxin, diverse groups and individuals, including some healthcare practitioners, began to think about the use of materials in hospitals and the medical waste stream more critically and ask what constitutes a "healthy hospital." In addition to community activists and environmental advocates, growing coalitions included some surprising partners:

- Dairy and beef cattle farmers were concerned because of dioxin contamination of milk and meat products, a result of airborne dioxin falling out onto pastureland. According to the EPA, beef and dairy products remain among the leading sources of dioxin exposure for adults in the United States.
- Mothers were distressed to learn that their fat-laden breast milk contained enough dioxin to expose newborn infants to up to 10 percent of an anticipated lifetime dose during the nursing period -- a matter of intense concern as infants of all species seem to be more susceptible to the toxicity of dioxin than adults.
• People catching and eating fish worried not only about contamination with dioxin but mercury as well -- another developmental poison discharged from medical waste incinerators. State health agencies in many states advised pregnant women and women of child-bearing age not to eat native freshwater fish because of unsafe levels of mercury.

Various groups have begun to coordinate their efforts to address common concerns. In September 1996, a diverse group of community activists, scientists, and healthcare professionals met in Bolinas, California to begin developing a national approach to educate and assist in the transformation of healthcare materials use policies and waste management practices. The Healthcare Without Harm coalition is launching initiatives around the country, and the coalition is gaining new members.

**Important Role of the Medical Community**

The medical community has begun to recognize an ethical responsibility to address these issues and insist upon changes in products and practices. In 1994, the American Public Health Association (APHA) called for a timed phase-out of the production and use of materials which lead to the creation and release of persistent toxic substances, including chlorinated organic chemicals -- a source of building blocks for dioxin. In 1996, the APHA recognized the relationship between medical waste incineration and dioxin formation and called for steps to minimize dioxin generation and release. Members recognized the need for a fundamental re-examination of materials and purchasing policies with the intent of reducing the use of hazardous products and keeping them out of the waste stream as much as possible without compromising patient care. Similar resolutions have been approved or are pending before several state medical societies, including those in Maryland, and the American Medical Association.

Some individuals have been working for years to raise awareness of these issues. Hollie Shaner, RN has called upon her healthcare colleagues to examine the public health impacts of their own actions. A leader in medical waste reduction and materials management, she has written and lectured widely on the subject. Her personal laboratory is Fletcher-Allen Health Care in Burlington, Vermont, a hospital which has instituted extensive waste reduction efforts which save hundreds of thousands of dollars and reduce pollution. "It is vital for nurses to understand the most pressing environmental issues and the consequences to human health resulting from them," she says.

More recently, additional physicians and nurses, along with other community activists, have begun to lead efforts to raise awareness of the environmental impact of material production, purchasing, use, and disposal. They seek to enlist their colleagues in a campaign to integrate, beyond the treatment room, the principle of "do no harm". According to Drs. Michael McCally of Mt. Sinai School of Medicine in New York and Peter Orris of Cook County Hospital in Chicago:

Health professionals have...an obligation to alert those at risk to the presence of danger to their health...Given that global dioxin pollution has profound implications for the health of individuals
and communities and that medical waste contributes substantially to the pollution, health professionals bear a responsibility to act to prevent dioxin exposure. Health professionals may be able to treat some of the health conditions caused by dioxin but can not cure them. When cure is not possible and prevention is effective, prevention is ethically required.

Citizen activism, legislation, and anticipated regulations have created opportunities and incentives for health care facility administrators and departmental managers to address purchasing and disposal policies. Alternative technologies such as autoclaving, steam sterilization, and chemical disinfection are being examined as waste treatment options. Economic, public health and environmental concerns are forcing a critical examination of the composition and volume of the medical waste stream.

Challenges to Reform
In 1997, well after the deadline required by the 1990 Clean Air Act Amendments, the EPA issued new MWI regulations. Because various industry and lobbying groups encouraged the agency to weaken proposed standards, exempt small incinerators from any oversight, and ignore the Clean Air Act requirements for maximum achievable control technologies, the standards are not even as strict as they would be had the EPA followed its own methodology. Groups that contributed to this watering down of the legally correct standards include The American Hospital Association, the Vinyl Institute and the Chlorine Chemistry Council. The American Hospital Association (AHA), an influential lobbying organization, called early EPA proposals overly restrictive, unnecessarily costly, and burdensome. It challenged the EPA estimate of the contribution of MWIs to environmental and human dioxin levels and disagreed with EPA's preliminary conclusions about the toxicity of dioxin. Similarly, the Vinyl Institute and Chlorine Chemistry Council commissioned a study which claims to show that polyvinyl chloride (PVC) is not an important source of chlorine for dioxin formation in waste incinerators.

The effect of such intense lobbying is evident in EPA's new regulations. The regulations include no mention of pollution prevention through source reduction or materials use changes. Incinerator operators are allowed to inspect their own facilities and compliance testing is only required at the time of initial start-up of an incinerator. Small incinerators have more lax emission limits, and even large existing incinerators are allowed to operate with less than maximum achievable control technology. The regulations rely on incinerator operators being knowledgeable about and committed to "good combustion practices". This focus on a negotiated acceptable level of pollution resulted in a missed opportunity to substantially reform the approach to healthcare materials management.

The state of Maryland has an opportunity to remedy such problems when drafting Maryland's regulations. The EPA regulations are minimum requirements, and MDE may surpass them and remedy all of the above situations. However, MDE is subject to the same political pressures as the EPA, and has chosen in its proposed regulations largely to comply with the EPA's standards. If these regulations are passed, another enormous opportunity to reform the approach to healthcare materials management will also have passed.
A Focus on Healthy Hospitals

The goal of the various individuals and coalitions concerned about the environmental and public health impacts of medical care is more than the elimination of dioxin emissions from MWIs, though this issue has been a recent catalyst. The overarching vision is one of healthy hospitals and healthcare facilities within healthy communities, called sustainable healthcare by some. This broader perspective includes not only disease treatment and prevention, but also pollution prevention and, most importantly, commitment to practices which are sustainable and protective of the environment for future generations.

A number of medical products contain hazardous materials which could immediately be eliminated from production and use without compromising patient care or adding to healthcare costs. In turn, production and healthcare workers as well as the larger community and general environment would benefit. In other cases, new products will need to be developed before those currently used can be replaced. But manufacturers will have no incentive to develop safer products unless and until they are driven to it by regulations or customer demand. This report discusses some of the unique features of medical materials purchasing, use, and disposal practices as well as the culture of healthcare institutions themselves. For those interested, references provide suggestions for additional sources of information. Many partners are available around the region and country willing to share their own experiences and identify opportunities for addressing a public health issue for which the healthcare community has a unique responsibility.
Chapter 1

The Maryland Incineration Picture

This chapter presents an analysis of the information currently available about medical waste and medical waste incinerators in Maryland and the existing and proposed regulatory regime for medical waste incinerators (MWIs). This analysis reveals a number of concerns.

Findings:

1) There are 41 medical waste incinerators (MWIs) in Maryland, including the largest MWI in the world.

2) Thirty-one of the 41 MWIs (75%) do not have air pollution control devices. MWIs that do have pollution control are largely equipped with devices designed to capture particulates and acid gases, not dioxin and mercury, toxins of critical public health concern.

3) Many of the MWIs operating in Maryland have additional characteristics making them high risk for emissions of and exposure to toxic air pollutants, including intermittent operation and location in commercial or residential neighborhoods.

4) Maryland MWIs burn 42,069 tons of medical waste each year — 16% above the national per capita average. Maryland healthcare facilities produce 35,219 tons of mixed medical waste and 5,973 tons of pathological medical waste annually, according to MDE and EPA estimates. There are no requirements for healthcare facilities to reduce or recycle their waste.

5) Maryland MWIs are a major source of dangerous toxins. According to MDE data, Maryland MWIs release 968 pounds of mercury and up to 447,000,000 micrograms of dioxin each year. Mercury and dioxin have been linked with serious health problems in trace amounts. In 1996, tests conducted at Phoenix Services, Inc. in Baltimore found that average dioxin emissions were 5 times greater than the EPA’s proposed standard for existing MWIs and 200 times greater than the EPA’s proposed standard for new MWIs. After Phoenix Services, Inc. installed expensive pollution controls, it met the laxer dioxin standard but still exceeded EPA’s mercury pollution standard by 40%.

6) Children, minorities, and the poor are the victims of this pollution. While only 18% of white people live near a MWI, 34% percent of Maryland’s minority
population, 43% of people in poverty, and 240,633 children live within 2 miles of a medical waste incinerator, according to a 1996 Environmental Working Group report.

7) **Only two medical waste incinerators regularly test for toxic emissions.** Although MWIs are inspected once a year by MDE, inspection merely includes looking at the unit, recording the operating temperature and the amount of material charged in the unit, and checking for visible emissions. Inspection does not include a stack test to measure pollution output. In fact, no MWIs in the entire state of Maryland have ever undergone stack tests with the exception of three incinerators, all of which have some pollution controls.

8) **Most current permits for MWIs focus on the concerns known at the time they were granted** -- particulates and acid gases -- and have not been updated to address other serious health threats, such as dioxin and mercury.

9) **The proposed MDE regulations for MWIs fail to protect public health.** The draft regulations do not contain any requirements for pollution prevention, such as waste reduction and recycling, or set emission standards for a number of important pollutants, including arsenic, chromium, nickel, and PCBs. The proposed standards would allow 19 times more dioxin emissions than standards in some European counties, and nearly 4 times as much mercury as allowed in Florida or New York.

**A Need for Better Information**

A lack of definitive information makes it difficult to define the scope of the hospital waste situation in Maryland. Some information is simply not available. Healthcare facilities are not required to report how much waste they produce. Nor are hospitals and most MWI operators required to monitor toxic air emissions from MWIs.

While MDE has generated estimates of uncontrolled toxic emissions from MWIs, MDE officials warn the figures are rough estimates. These estimates conflict with others produced at MDE. Because some MWIs have pollution control devices, some figures may overestimate the amount of pollutants actually released. However, MDE officials have also said that when proposing new regulations, it is customary to generate new data about the area the regulations will effect so that they are appropriate. Because MDE is proposing new regulations for MWIs, it would seem logical then that MDE compile more accurate data. MDE justifies their lack of action by saying that EPA has already compiled the necessary data and formulated the appropriate regulations. However, based on MDE and EPA estimates, Maryland burns 16% more medical waste per capita than the national average. EPA's floor regulations may not, therefore, be relevant for Maryland. Better monitoring of Maryland MWIs would remedy this situation, and then MDE could propose regulations appropriate for Maryland.

MWIs are also not the only incinerators burning medical waste; municipal solid waste incinerators
may also burn some medical wastes (though not pathological wastes), including out-of-state materials. Some MWIs are also permitted to accept out-of-state waste, and some Maryland medical waste may be exported out of state to be burned. Maryland imports 877 tons of medical waste annually from Virginia, West Virginia, and the District of Columbia. Phoenix Services, Inc. is permitted to import waste within a 250-mile radius, extending as far as New York. The amount of waste imported will likely increase as surrounding states adopt new regulations and smaller incinerators shut down.

Figures indicating that Maryland burns significantly more waste than the EPA's per capita average, the fact that Maryland is the home of the largest incinerator in the world, and indications that Maryland's importation of other states' medical waste will increase with the adoption of stronger incinerator standards all indicate that Maryland's medical waste problem is worse than EPA's rules reflect.

**Characteristics of Maryland Medical Waste Incinerators**

Many of the MWIs operating in Maryland have characteristics making them high risk for emissions of and exposure to toxic air pollutants. These include a lack of pollution controls, intermittent operation, and location in commercial or residential neighborhoods.

Thirty-one of the 41 MWIs in Maryland do not have air pollution control (APC) equipment. Those which are equipped with APC equipment primarily have devices such as scrubbers and baghouses which are designed to capture particulates and acid gases, not heavy metals and dioxin. The exception is Phoenix Services, Inc., which installed vortex bags last summer to catch dioxin and mercury emissions.

In addition, most of the state's MWIs are "intermittent incinerators," meaning that they are not operated on a continuous basis. An intermittent incinerator is fired up only when a hospital accumulates sufficient waste. Startup and shutdown periods have been linked to high concentrations of toxic emissions. Because optimum combustion conditions are more difficult to achieve and sustain in intermittent incinerators, they are believed to emit even higher amounts of dioxin than continuous incinerators such as those operated by Phoenix Services, which emitted over 5 times as much dioxin in a 1996 test than allowed by MDE's proposed standards for existing incinerators.

The state's numerous on-site MWIs may also be sited in areas where exposure to air emissions is high. Almost one-third of Maryland's MWIs are located in Baltimore alone, including the largest MWI incinerator in the world. Many hospitals occupy commercial or residential neighborhoods, surrounded by other buildings of similar height. These buildings may have air intakes that draw contaminated air from a nearby MWI. In fact, the hospital's own fresh air intakes may be drawing in contaminated air.
The Largest Medical Waste Incinerator in the World

Phoenix Services, Inc., the largest medical waste incinerator in the world, has a long and controversial history in Baltimore.

In 1988, the nation was in the midst of a growing AIDS scare, and disposal companies were charging upwards of $800 per ton for infectious waste disposal. A group of extraordinarily well-connected businessmen\(^2\) wanted to get a piece of the medical waste disposal market and formed Medical Waste Associates, Inc. (MWA). A deal was struck between MWA and the Maryland Hospital Association such that a regional incinerator would be built and that local hospitals could sign 20-year contracts with MWA to take all hospital waste for $300 per ton. The deal got the backing of Mayor Kurt L. Schmoke because the incinerator would have allowed smaller, dirtier hospital incinerators to shut down. Schmoke, however, withdrew his support when it became clear that some local hospitals wouldn't take the deal. MWA won back Schmoke's support by promising to take only wastes from the Baltimore region. The incinerator was built in Hawkins Point, Baltimore in 1990, financed by tax-free state loans, with a capacity so large that it can burn 170 tons of medical waste a day -- 1.5 times the amount of waste generated in all of Maryland.

Within months of opening, the MWA incinerator was taking wastes from outside the Baltimore region. Meanwhile costs and bad management also took their toll. By 1992, city auditors had determined that the MWA was in financial After the city successfully defended a lawsuit over the agreement to limit the so-called "catchment area," the Schmoke Administration and MWA agreed to settle the lawsuit and avoid appeals by expanding the catchment area to include some of the DC metro area. A controversial City Council vote in 1993 gave the approval for this expansion. By 1994, however, MWA was bankrupt.\(^12\)

By the spring of 1997, the incinerator had changed hands. Funded by a venture capital firm, Phoenix Services, Inc. took over the facility, buying it out of bankruptcy for pennies on the dollar. In order to be competitive and retain its union workers, Phoenix Services said, the incinerator needed to once again expand the catchment area. And after another controversial vote, the incinerator was allowed to take wastes from as far away as 250 miles -- significant because it would allow Phoenix to enter the New York City market.\(^13\) Then in June, the company locked

\(^2\) The five founders included the late William Boucher III, former head of the Greater Baltimore Committee, Thomas McKewen, former head of the Maryland Environmental Service, and the late Harry McGuirk, a former state senator. The group brought in three wealthy African-American investors, Otis Warren and Theo Rogers, both prominent developers, and Raymond Haysbert, then chairman of Parks Sausages.

\(^3\) During this time, three of MWA's founders attempted to build a similar facility on tribal lands of the Santa Rosa Indian Tribe in California. After news of the Baltimore facility's financial difficulties reached tribal leaders, they rejected the proposal.
out its union workers. The well-trained union workers were replaced by cheaper, non-union workers without the job protections provided for reporting problems of environmental health and safety.  

According to MDE estimates, Phoenix Services historically has been responsible for over 50% of all dioxin and mercury pollution emitted by Maryland medical waste incinerators. In 1996, tests conducted at Phoenix Services found that average dioxin emissions were 5 times greater than MDE’s proposed standard for existing MWIs and 200 times greater than MDE’s proposed standard for new MWIs. After Phoenix Services installed expensive pollution controls, it met the laxer dioxin standard but still exceeded MDE’s proposed mercury pollution standard by 40%.

Adding insult to injury, Phoenix’s contract requirements discourage hospitals from reducing their waste stream through environmentally-conscious “reduce, reuse, recycle” practices. Coined by environmentalists as “put or pay,” clients contract for a certain amount of trash to be burned and then pay for that amount regardless of whether they deliver less. Taken to its extreme, even if a hospital implements a successful recycling and waste segregation policy, it would be required to pay Phoenix Services during the contract period as if the incinerator were burning the maximum load. Thus, the cost benefits of recycling and waste segregation would be nil.

**Mercury**

Because most MWIs are small units, the Environmental Protection Agency does not require emissions monitoring, nor does the state require routine monitoring. However, MDE did conduct stack testing at 3 MWIs. Based on this testing and data from national studies, MDE estimates that MWIs are responsible for emitting 968 pounds of mercury each year. Mercury is highly toxic in trace amounts: a drop of mercury as small as 1/70th of a teaspoon can contaminate a 25-acre lake to the point that the fish in it are unsafe to eat.

The Massachusetts Department of Environmental Protection has also found that both the ash leftover from incineration ("fly" and "bottom" ash) and emissions control devices also contain mercury. The Massachusetts Department of Environmental Protection estimated that this additional mercury would range from 10 percent to 50 percent of stack emissions. This mercury waste is land filled, giving it the possibility to leach into the environment.

**Emissions Testing is Virtually Non-Existent**

With the exception of three facilities, none of the MWIs in Maryland have undergone stack tests for toxic pollutants. This has led to a lack of information on the amount of mercury, dioxin and heavy metals emitted into the environment. MWIs may be emitting more harmful toxins than permitted, but no one would know under the current regulations.
Current Regulations Inadequate

The current regulations, including standards and inspection and monitoring requirements, are inadequate. There are no MWI emissions standards for many of the most dangerous toxic air emissions, such as mercury and dioxin. Currently, the only standards are for carbon monoxide, particulates and hydrogen chloride. Stack tests to measure toxic air emissions are not part of a standard inspection.

While some MWIs are permitted to just burn pathological waste, there is no question that hospitals are burning what goes in the red bags -- and what goes in the red bags is more than just pathological waste. This red bag waste is likely to contain materials, plastics in particular, that MWIs were not designed to burn. Yet, not surprisingly, MDE inspectors do not sort through the red bags to determine whether an MWI is burning non-pathological wastes.

Another concern is the ash generated by MWIs, which must be put somewhere, most likely in a landfill. As noted earlier, the Massachusetts Department of Environmental Protection estimated that MWI ash may contain 10-50 percent as much mercury as is emitted from the stack. In addition, the EPA's draft dioxin reassessment suggests that MWI ash may be a source of dioxin. The assessment does not contain an estimate for dioxin in MWI ash, but it does include one for dioxin in ash from municipal solid waste (MSW) incinerators: the central range estimate is 1,800 grams toxic equivalency factors (TEQ) per year -- a figure which is 60 percent of the comparable estimate for air emissions.16 MSW incinerators have better air pollution control systems than most MWIs; hence, a greater percentage of dioxin output is likely to be in ash. However, given the greater chlorine content of hospital waste, it is likely that MWI ash is a significant source of dioxin. In 1998, Phoenix Services alone generated 7,399 tons of ash.17

There are two possible points of exposure to contaminants in MWI ash. One is from leaching of the contaminants from landfills into groundwater. Another point of exposure is direct contact by workers involved in handling, transportation, and land filling of the ash, and by nearby residents. Classification as "ordinary" solid waste may lead to dangerous mishandling of what is actually a highly toxic waste.

Proposed Regulations Inadequate

The 1990 Clean Air Act Amendments mandated that the EPA regulate MWI emissions for an extensive list of pollutants: dioxins and furans, particulate matter, carbon monoxide, hydrogen chloride, sulfur dioxide, nitrogen oxides, lead, cadmium, and mercury. The law required that the EPA promulgate the MWI regulations by November 1992. When that deadline was missed, the Sierra Club and the Natural Resources Defense Council (NRDC) sued. In a court-approved settlement, the EPA agreed to a new deadline of April 15, 1996. That deadline was also missed. The Sierra Club and NRDC agreed to an extension until July 25, 1997.

More fundamental than the missed deadlines, however, environmental organizations have criticized the content of the EPA regulations themselves. Criticism has focused on a number of
areas, including the lack of requirements for pollution prevention (as opposed to pollution control), the proposed exclusion of small MWIs from regulation, and the poor standards.

Pollution control versus pollution prevention
The Clean Air Act calls for both pollution control (through control devices and better MWI operation) and prevention (such as recycling and reducing the use of PVC). For example, Section 112 directs the EPA to determine the major sources of dioxin, furans, and mercury, and develop standards for these sources which include source reduction and pollution prevention requirements.

However, the new EPA standards and correlating MDE proposed regulations for MWIs rely solely on pollution control. The standards do not address the opportunity to intensively recycle the municipal-type waste in medical facilities (much of which is burned in MWIs), nor do they mention waste prevention practices. By focusing solely on pollution control, this approach will not sufficiently protect public health from MWI emissions.

Pollution control equipment does not prevent pollution; it merely contains it. For example, a scrubber on an incinerator smokestack will collect heavy metals and dioxins, which will then go into the fly ash residue. This ash will then be land filled (and in the process, be handled by workers), with the potential for the pollutants to leach into the environment. Moreover, the efficacy of air pollution control devices hinges, in large part, on the quality of their operation and maintenance.

Finally, many of the pollutants emitted by MWIs, such as dioxin and mercury, are very persistent in the environment; they accumulate in bodies of water, food, and living beings. As a result, MDE standards -- which reduce, but do not eliminate emissions -- will not stop the accumulation of toxic chemicals in the environment and living beings.\(^{18}\)

Weak standards
Criticism has been aimed at the pollution control numerical standards and control device requirements for MWIs. The proposed standards would allow 19 times more dioxin emissions than standards in some European countries. MDE's proposed mercury standard is less rigorous than standards set by several states. For example, MDE's proposed standard is 550 \(\mu\)g/dscm, while Florida's is 140 \(\mu\)g/dscm and New York's is 130 \(\mu\)g/dscm.

The requirements for emissions control devices are more stringent for other types of incineration, municipal solid waste (MSW) and hazardous waste, than for medical waste incineration. In particular, the EPA standards for MSW and hazardous waste incinerators require the use of carbon injection systems, while those for MWIs do not.\(^{19}\) Carbon injection systems, though expensive, are very effective at removing dioxin and mercury from fine gas emissions, and may represent the "maximum achievable control technology," the standard required by the Clean Air Act. The exemption of MWIs from meeting that standard violates the Act.

Finally, it should be noted that it will take a very long time for the EPA's regulations to take
effect. They were issued in 1997, and MDE will hold a public hearing on the regulations in late November 1999. Once MDE does submit its regulations, the EPA then has another year to approve them and the facilities have another year after approval to comply.
Chapter 2

Healthcare Materials and Medical Waste Toxicity

Introduction
The amount of hospital waste generated in the United States is about 2.4 million tons per year -- approximately 1 percent of the municipal waste stream. This does not include physician, dental, and veterinarian offices, nursing homes, outpatient facilities, and blood banks. The EPA estimates that about 2 million tons of this waste are burned annually in medical waste incinerators. Moreover, healthcare facilities which segregate regulated waste for disposal in MWIs often send their unregulated waste to municipal solid waste incinerators, adding to the combined incinerator volume.

Medical waste incinerator (MWI) emissions depend on the design or type of incinerator (e.g., rotary kiln, controlled air, heat recovery, pollution control devices, etc.), intermittent vs. continuous operation, composition of waste, operator skill, operating parameters (e.g., temperatures, pressures, oxygen levels, rate of feed, etc.), and level of maintenance. Dioxins and furans, sulfur dioxide (SO2), particulates, and hydrochloric acid (HCl) are released to the environment from MWIs. Metals in medical waste, including mercury, arsenic, cadmium, chromium, iron, manganese, nickel, and lead, are also found in MWI emissions. Dioxins and metals contaminate incinerator ash. The following sections address the toxicity of some of these pollutants in more detail.

Determinants of Toxicity
Medical waste composition and methods of handling and disposal largely determine its toxicity. It contains about twice as much plastic as ordinary municipal waste. Some metals, discarded drugs, and laboratory chemicals in the waste are toxic. Needles and other sharp objects that may cause injury require special handling. During use, medical materials may become contaminated with bacteria, viruses, or other infectious organisms. Concern about infections prompts some waste handlers to treat all hospital or medical waste as potentially infectious - a practice largely without justification (see Chapter 4 for further discussion of this point). Convenience, cost, quality of care, labor-saving, and availability of storage space during materials production, use, and disposal are considerations which also influence waste volume and toxicity.

Incineration of trash creates hazardous air emissions, contaminated wastewater, and toxic ash. A truly comprehensive toxicity analysis of materials used in healthcare also needs to consider their production and use as well, including impacts on production and healthcare workers, residents in nearby communities, and ecosystems. For example, dioxins are also formed in chlorine and
polyvinyl chloride (PVC) production. This life-cycle perspective involves multiple industries such as plastics, pulp and paper, metals, adhesives, radioisotopes, solvents, fixatives, other laboratory chemicals, woodworking, electrical, and pharmaceuticals.

**Dioxin**

Dioxins and furans are groups of persistent toxic chemicals, with no commercial or industrial use, which are produced as unwanted byproducts of certain industrial processes involving chlorine production, use, and disposal. Municipal, medical, and hazardous waste incinerators are leading dioxin sources. Dioxins are organic compounds with varying numbers of attached chlorine atoms on each molecule. Their toxicity varies considerably, depending, in part, on the number and position of the chlorine atoms. The most toxic form of dioxin is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Because mixtures of dioxins and furans may vary considerably in their composition, the concept of "toxic equivalency factors" (TEQs) is used to compare the less toxic to the most toxic (TCDD). A mixture, then, may be described as equivalent to a given number of TEQs which makes it possible to compare one mixture to another.

Dioxin formation in incinerators depends on a number of interrelated factors including the chlorine and metal composition of the waste stream as well as incinerator design, operating conditions, and maintenance (see discussion below). The estimated contribution of MWIs to environmental dioxin contamination has been the subject of considerable debate. As some MWIs have closed, waste has been increasingly transferred to larger, newer regional facilities or disposed of in alternative ways (including municipal waste incinerators). Incinerators of improved design, equipped with more effective air pollution controls, and carefully operated and maintained emit less dioxin to the air than others. It is, however, generally agreed that MWIs continue to represent one of the top two or three sources of dioxin.

Dioxins and furans released into the atmosphere may be transported long distances before settling onto soil or water, accounting for global distribution. Dioxin-containing incinerator ash is disposed of in landfills. The compounds tend to cling to surfaces and particles and are not easily washed away or biodegraded. They accumulate in soils and on the leaves of plants. In water, dioxin attaches to particles and slowly settles into sediments. The food supply of grazing animals and fish is contaminated, and the dioxin stored in fatty tissue is concentrated and passed up the food chain.

**Health Effects of Dioxin**

The health effects of dioxin have been extensively studied in animals and, to a lesser extent, in humans. Binding to a cellular receptor is necessary for a dioxin molecule to exert its biochemical and toxic effects, though some investigators question whether this is how dioxin interferes with the immune system. The dioxin-receptor combination is transported to the nucleus of a cell where it binds to DNA, interfering with the normal expression of genes. This, in turn, alters enzyme production and interferes with the function and metabolism of various hormones, growth factors, and other chemicals.
Dioxin causes cancer in laboratory animals, and several studies of humans exposed to larger amounts than likely from the general environment show an increased incidence of various forms of cancer. It is also toxic to the immune system and interferes with normal reproduction and development. Primate studies show an association between dioxin exposure and endometriosis -- growth of the lining of the uterus in abnormal locations such as the inner abdominal wall or fallopian tubes. In human infants, dioxin lowers levels of thyroid hormone -- a hormone necessary for normal brain development. This effect was demonstrated in a study population from an industrialized area in the Netherlands where fetal and nursing exposures to dioxin-like compounds were not out of the ordinary. Some occupational or large accidental exposures cause a persistent disfiguring acne-like skin rash (chloracne), weight loss, fatigue, decreased libido, altered glucose metabolism, and neurological damage. In animal studies, susceptibility to the different forms of toxicity varies considerably among species. This variability is less marked, however, among fetuses and newborns, with some health effects detectable at doses well below those which have no effects in adults. There is also evidence of considerable variability of susceptibility among individuals.

Cancer
Dioxin exposure causes cancer in virtually all studies in experimental animals at doses well below those which have no other apparent health effect. Carcinogenesis is a multi-stage process. An initial event must be followed by progression through several stages before a malignancy actually appears. Cancer promoters facilitate this progression, but they do not initiate the process. Though dioxin does not appear to be a cancer initiator, it behaves as a potent promoter. It modifies hormones involved in cell growth and differentiation which may explain, in part, how dioxin exposure causes an increased incidence of many different types of tumors. Experimental animals exposed to dioxin under varying circumstances develop cancers of the liver, adrenal gland, thyroid, skin, lung, nose, and palate. In rats, thyroid tumors occur at doses as low as 1.4 nanogram/kg/day (a nanogram is one thousandth of a microgram).

Studies of cancer in humans exposed to dioxin have produced mixed results. Some show increased incidence of soft-tissue sarcoma, non-Hodgkin's lymphoma, and nasopharyngeal cancer. A particularly comprehensive study of workers from 12 different industrial facilities showed increased mortality from soft-tissue sarcomas and all cancers among those exposed to dioxin. Others have not found similar increases. Dioxin is classified as a known human carcinogen by the International Agency for Research on Cancer.

Immune system toxicity
Dioxin's effects on antibody response and other forms of immune-system expression have been extensively studied and documented. In experimental animals, dioxin exposures of less than one microgram/kg have caused a decreased immune response and increased susceptibility to viral, bacterial, and parasitic infections. Prenatal exposure of animals to dioxin at low levels can cause increased growth of transplanted tumor cells in offspring. This may represent immune-system toxicity since the immune system plays an important role in cancer surveillance and suppression.
A number of studies in humans exposed to dioxin have shown effects on various measurements of the immune system in blood tests. The health significance of these changes is not well understood. More research is needed to determine if these changes are correlated with increased susceptibility to infection or more severe disease.

Reproductive and developmental toxicity
Animal studies show that dioxin exposure is associated with decreased fertility, decreased litter size, and inability to carry pregnancies to term. Maternal exposure results in offspring with lowered testosterone levels, decreased sperm counts, birth defects, and learning disabilities. Many of these effects are seen at exposure levels well below those where no effects are seen in adults, demonstrating the exquisite sensitivity of the developing fetus to dioxin. In one rat study, a single low maternal dose of dioxin (0.16 micrograms/kg) on day 15 of pregnancy reduced male testosterone levels, delayed descent of the testicles, made the genital area more female-like, and reduced sperm counts and prostate weight in male offspring. It also permanently demasculinized their behavior.

Human studies have reported lowered testosterone levels in exposed workers and birth defects in offspring of Vietnam veterans exposed to Agent Orange, an herbicide containing dioxin.

Human exposure to dioxin: cause for concern
Most human exposure to dioxin occurs through the ingestion of contaminated food rather than inhalation or absorption through the skin. Foods of animal origin are the major dioxin source with beef providing about 30 percent of the daily intake among meat eaters. Dairy products, chicken, pork, fish, and eggs account for most of the remainder.

Because dioxin tends to collect in fatty tissue, maternal milk, with a high fat content, contains large amounts of dioxin. Nursing infants may receive more than 10 percent of their anticipated lifetime dose of dioxin during this particularly vulnerable period of mental and physical development. Other highly exposed groups include those whose diets contain large amounts of fish taken from contaminated waters or marine mammal fat which may be contaminated from the buildup of dioxin as it passes through the food chain and collects in fat tissue.

The EPA estimates the average exposure of adults to be 1-3 picograms TEQ (TCDD equivalents)/kg/day (one picogram is one-millionth of one microgram). The half-life of dioxin in humans is about 5-10 years so that daily exposures tend to build up in fatty tissue over time leading to an average of 40-60 TEQ picogram/gm fatty tissue when all dioxins, furans, and dioxin-like PCBs are considered. The EPA estimates that approximately 10 percent of the population may have levels that are three times higher.

Animal studies have shown that dioxin causes the liver to produce metabolic enzymes at exposures of 1-10 TEQ picograms/kg/day, which is similar to human exposures. This enzyme induction occurs at levels which also cause immune system toxicity in mice and reproductive effects in rats. This means that current exposures in humans are now in the range where
biological changes and adverse effects are seen in animals.

**PVC Incineration: A Source of Dioxin**

Polyvinyl chloride (PVC) is a type of plastic used to make many medical products such as blood and IV bags, tubing, other medical devices, gloves, packaging, and patient ID bracelets. It is approximately 50 percent chlorine by weight. Hospital trash contains a higher percentage of PVC than ordinary municipal waste. But, the medical uses of PVC are only a small fraction of its current and projected applications throughout the world. Other PVC products include pipe and pipe fittings, coatings, floorings, flexible and rigid materials used for construction and various devices, wire and cable, bottles, films, and sheets for shower curtains, waterbeds, etc. The vinyl plastics industry reached a worldwide market with 46 billion pounds in 1995. U.S. exports to developing countries are projected to increase rapidly.

The importance of the public health and environmental consequences of PVC combustion should not be underestimated. Though there is considerable debate over the details, combustion chemists generally agree that hydrocarbons, chlorine, and heat are necessary for dioxin formation. In incinerators, equipment design, operating conditions, maintenance, rate of feed, and composition of waste all influence dioxin generation. Some metals facilitate (catalyze) the process. Some dioxin is formed on metal-coated fly ash as the exhaust from an incinerator cools. There may also be dioxin formation in the gases of burned material. While there is controversy regarding the precise relationship between the PVC content of waste and incinerator emissions of dioxin, the important practical question is whether a reduction in PVC input will result in a reduction in dioxin output from a particular incinerator -- or from all of the incinerators in use today.

Most evidence indicates that, during combustion, PVC is an important source of chlorine for dioxin formation -- and that increasing PVC input increases dioxin output. A recent study from an internationally recognized Swedish incineration laboratory notes that of twenty studies examined, 14, or 70 percent, found a correlation between PVC input and dioxin output. Some suggest there must be a minimal threshold of PVC in the waste feed before it influences total dioxin production. One shows that poorly-controlled combustion can result in 10 times more dioxin than well-controlled combustion of similar waste. This observation bears directly on proposed MDE regulations which rely heavily on promises of good combustion practices as the only monitoring and enforcement tool for some medical waste incinerators. The combination of high chlorine content of medical waste (much of which is in the form of PVC) and poor combustion practices creates a virtual dioxin factory.

**Industry responds**

In 1990, industry convinced the EPA to reassess the toxicity of dioxin, believing that regulators were overestimating its hazards. The EPA reassessment has confirmed its wide-ranging toxicity at low exposure levels. Now, industry has attempted to show that burning PVC does not contribute substantially to environmental dioxin levels.
Data from dozens of burns in dozens of municipal and several medical waste incinerators have been assembled and interpreted in a report prepared for the American Society of Mechanical Engineers, and funded by the Vinyl Institute, Chlorine Chemistry Council, and Environment Canada. Many believe this analysis was commissioned to silence calls for a pollution prevention approach from environmentalists focusing on using alternatives to chlorinated plastics to lower dioxin emissions. The authors, Rigo, et. al., concluded that their analysis does not support a relationship between fuel chlorine content and dioxin concentrations.

The Rigo analysis and its conclusions require critical review. The authors use various statistical techniques to pool an impressive amount of data from 155 different incinerator facilities. But these data were initially collected for other purposes -- not in order to examine the relationship between PVC and dioxin. Their attempt to use the available information for their purpose requires assumptions and mathematical and statistical techniques which ignore important data limitations and bias the results toward finding no relationship between waste feed chlorine content and dioxin. But in spite of the problems of data limitations and statistical bias, the majority of MWI studies analyzed by Rigo, et. al. actually did show a positive correlation between hydrochloric acid (HCl), used as a surrogate for PVC, and dioxin -- that is, an increase in dioxin output with increased chlorine input. They reported it otherwise.

In general, to determine whether changes in one variable (PVC content of waste feed) influence a second variable (dioxin emissions), the most appropriate method is to vary the first as widely as possible and note the effect on the second -- holding all other factors as constant as possible or, at least, carefully controlling for changes in other factors. However, these conditions were not met in the industry analysis. For example, there was little variation in PVC content (or its surrogate, HCl) of the waste feed. Moreover, the data were collected from scores of different incinerators of different design and operating conditions, introducing numerous other relevant variables into the analysis simultaneously.

Since the actual PVC content of the waste was known for virtually none of the test burns, the authors used hydrochloric acid (HCl) in the exhaust stream as a surrogate for PVC input. This strategy immediately injects inaccuracies into the analysis because PVC content of the input is exactly what we are interested in. Thomas and Spiro, Princeton University combustion experts, have concluded that HCl gives only a lower bound estimate for chlorine in the original waste -- and others have shown that, for HCl to be a valid surrogate for PVC, waste feed rates and sampling techniques must be taken into account. The industry-sponsored analysis does not consider these variables, limiting the value of HCl as a PVC surrogate. Moreover, dioxin samples in the test data examined by Rigo, et. al. were taken from various sites in the exhaust stream -- from boiler outlet to farther downstream in the exhaust flow -- predictably a source of variability since dioxin can actually be formed at various points in the exhaust, depending on temperature and fly ash composition.

These design and sampling strategies, along with other mathematical and statistical manipulations, limit the usefulness of the analysis to shed light on the question of interest. And the failure of the
authors to report the results in a way that points out the correlations that are, in fact, revealed lends support to the view that the analysis was commissioned for political rather than scientific purposes.

In the real world of medical waste incinerators of varying design, air pollution controls, operating conditions, and operator skill, PVC contributes substantially to the chlorine supply required for dioxin formation. The science advisory board of the EPA has noted that dioxin measurements in lake bottom sediments and soil samples clearly demonstrate that "environmental dioxin levels increased significantly beginning about 1935-40 and that the likely explanation for this observation is the introduction of chlorinated organic compounds (PVC and chlorinated pesticides are two examples) in the 1935-40 time frame. Although the details of dioxin formation are not yet quantitatively understood, the introduction of these chlorinated products into wastes that were combusted appears to be the most likely cause of the increased dioxin deposition measured in sediments."^{58}

The policy options for reducing environmental releases of dioxin fall into two categories. "End-of-the-pipe" solutions focus on better operated, more sophisticated incinerators with advanced air pollution controls. This expensive approach favors increased transfer of waste to large state-of-the-art regional incinerators and away from more heavily polluting incinerators of inferior design. It depends on vigilant monitoring of combustion conditions and limited equipment failures. A second approach is to limit the PVC content of waste feed by eliminating unnecessary uses altogether and substituting non-chlorinated products where possible. This choice would simultaneously reduce dioxin resulting from chlorine and PVC production. Non-PVC alternatives already exist for some medical-use products. A firm regulatory and healthcare-industry stance on this important public health issue would quickly establish incentives for developing others.

**Phthalates: A PVC Additive**

Phthalates are a family of chemical compounds with varied industrial and manufacturing uses. Some are added to PVC to provide flexibility and textural qualities. Over 1 billion pounds of over 25 different phthalate compounds are produced annually.^{59} The two most abundantly produced are diethylhexyl phthalate (DEHP) and dibutylphthalate (DBP). Their acute toxicity is low by ordinary measures. However, DEHP produces liver tumors in animal studies, and both the EPA and the International Association for Research on Carcinogens (IARC) classify DEHP as a human carcinogen. Moreover, low levels of DEHP interfere with reproduction of some aquatic species. Laboratory animal tests also raise new concerns about reproductive toxicity.

Phthalates are present in many foods as well as surface and drinking water throughout the world, raising serious concerns about exposures in virtually all ecosystems: humans, wildlife, and domestic animals. Phthalates also leach out of IV bags, tubing, and dialysis equipment into patients.^{60, 61} PVC medical waste sent to landfills instead of incinerators enables phthalates to leach into surface and ground water.
Analyses of food collected in 1993 led to estimates of total phthalate intake for adults ranging from 0.013 to 0.027 mg/kg/day for adults. However, infant formula measurements led to estimates of about 0.13 mg/kg/day intake during the first six months of life -- about 10 times as large. Though these estimates of food levels are below what was previously considered safe, new information raises concerns because some phthalates have weak estrogenic activity. In rat studies, females given 0.1-0.4 mg/kg/day of butylbenzyl phthalate (BBP) during pregnancy and lactation had male offspring with reduced testicular size and sperm counts. These findings have yet to be confirmed in additional studies but suggest that levels near those to which human fetuses and infants are already exposed may have significant harmful effects. DEHP was not tested in this experiment. The cancer-causing potential and new evidence of reproductive toxicity of these compounds is sufficient reason for reduction of their widespread use.

Metals

Each type of metal in medical waste has its own individual toxicity. Moreover, metal oxides resulting from waste combustion coat fly ash and catalyze dioxin formation. This complex chemistry is only partially understood, but reduction of the metallic content of incinerated medical waste may reduce dioxin formation as well.

There are numerous sources of metals in medical waste, particularly with increasing use of disposable instruments. Iron, chromium, and nickel are components of stainless steel in medical instruments. Chromium is also used in some plastic items as a stabilizer and in pigments. Lead is used as a pigment or stabilizer in "sharps" containers and infectious waste (red) bags. Cadmium and manganese are present in batteries used in disposable examination flashlights. Cadmium is also used as a pigment and stabilizer in paints and plastics and is present in red bags.

Mercury is of particular concern. This metal can exist in three different forms -- as the pure element, inorganic mercury compounds, and organic (usually methyl-) mercury. Each has different health effects. Within the healthcare industry, elemental mercury is used in some thermometers, blood pressure measuring devices, and batteries. Inorganic mercury is present in some electrical fixtures, lights, medications, and antiseptics. Mercury is also used in the industrial process which produces chlorine from salt brine -- a connection to PVC production. Incomplete mercury recovery results in releases to the environment.

Mercury

When elemental mercury or inorganic mercury compounds are heated or burned, mercury is either released into the atmosphere, trapped in ash, or carried away in wastewater, depending on incinerator pollution controls. Atmospheric mercury travels long distances before settling onto soil or water. Once deposited, some inorganic mercury is transformed into organic mercury by bacteria, and in the form methylmercury, it enters the food chain and builds up to high levels in fish.

Exposure to elemental (metallic) mercury is primarily by inhalation because it tends to vaporize
easily. This occurs when thermometers or mercury-containing blood-pressure-measuring instruments are broken. Elemental mercury causes a range of symptoms, depending on the level of exposure. Relatively low amounts may cause kidney damage. Larger amounts lead to kidney failure. Some studies of workers exposed to low levels of metallic mercury in the workplace show impaired psychological performance, memory, and neuromuscular and renal function.  

Studies in women, mostly dental assistants, are inconclusive about whether mercury increases the risk of spontaneous abortions. One large study found an increased risk of spontaneous abortion and other complications of pregnancy in exposed women. Inorganic mercury is also toxic to the kidneys.

Organic mercury is of more concern at environmental levels of exposure. Because of bioaccumulation and concentration, organic mercury can build up to dangerous levels in fish. Many states have fish advisories recommending that infants, children, and women of child-bearing age limit or avoid consumption of fish from local waters because of mercury contamination.

Organic mercury easily crosses the placenta and enters the brain of the fetus or infant where it interferes with normal brain development. Large exposures may result in severe mental retardation, lack of coordination, muscular weakness, visual loss, and delayed development. Smaller exposures result in abnormal muscle tone and reflexes with developmental delays. Though ongoing research is attempting to determine if there is a safe level of exposure, methylmercury is generally considered a major developmental toxin.

**Lead**

The toxicity of lead is well known from extensive human and animal studies. At high blood levels, lead causes anemia, kidney damage, and neurological toxicity. Intermediate levels are associated with hypertension. Lead accumulates in bone, and during pregnancy, maternal bone stores from a lifetime of exposure are partially mobilized into the circulation enabling the toxic metal to cross the placenta. Low levels impair neurological development of the fetus and infant. Decreased hearing, growth, and IQ are detectable at blood levels as low as 10 micrograms/deciliter — found in a significant number of young children in this country despite screening programs, the phase-out of leaded gasoline, and other product controls.

**Chromium**

The toxicity of chromium depends on its form. Both hexavalent and trivalent chromium are present in emissions from MWIs. Hexavalent chromium causes lung cancer in workers exposed to chromium dust and is classified as a known human carcinogen.

**Cadmium**

Exposures to cadmium may cause chronic lung disease, kidney damage, and hypertension. Animal studies identify cadmium as a carcinogen but evidence in humans is conflicting. Cadmium is also toxic to the testes and placenta in animal studies. Cadmium concentrates in the human placenta, and levels of exposure that cause placental toxicity are at least 10-fold lower than those that cause other toxic effects in adults, such as kidney damage. Animals exposed to cadmium
show birth defects (decreased weight gain, skeletal defects, brain damage, and facial malformations), perhaps related to placental toxicity. Definitive human studies of the developmental effects of cadmium are lacking, but animal data support classifying this metal as a likely reproductive and developmental hazard.

**Arsenic**

Small amounts of arsenic are present in emissions from MWIs. Arsenic is used in glass manufacture and this may be the source. The toxicology of arsenic is complex, depending on the form in which it exists. Inorganic arsenic, the most toxic form, is converted to organic arsenic in the body. Chronic exposure to inorganic arsenic may lead to neurological, liver, and blood vessel injury. The EPA considers arsenic a human carcinogen.
Chapter 3

Alternative Materials Management Policies: Reduce, Reuse, Recycle

Introduction

Many of the solutions to reducing the toxicity and volume of the products used and disposed of in healthcare facilities are comparable to those for other large-scale institutional settings, such as hotels and universities. From eliminating unnecessary packaging to recycling wastepaper, the "Three Rs"—reduce, reuse, recycle—are the backbone of the menu of options to reduce the volume of waste burned to just pathological waste (which comprises less than fifteen percent of the total hospital waste stream). Additionally, reducing the toxicity of the products used and disposed of by healthcare facilities requires substituting (where available) alternatives for products containing polyvinyl chloride (PVC), mercury, and other toxic substances.

The solutions being implemented by many hospitals and proposed by public health advocates can be grouped into the reduce, reuse, recycle hierarchy. The first two categories involve opportunities to prevent waste before the point of purchase. Recycling is the preferred method of waste management. In addition, alternatives to incinerating the remaining waste should be explored.

Solutions include:

1) Reduce
   - Unnecessary packaging
   - Unneeded product use
   - The purchase of products containing toxic materials, such as polyvinyl chloride and mercury

2) Reuse
   - Substitute reusable products for disposables

3) Recycle
   - Proper waste segregation, including eliminating unnecessary "red-bagging" of waste, not only saves money, but increases the amount of materials available to be recycled
   - Much of the materials which remain after reducing, reusing, and proper segregation are recyclable—-from paper products to metals to food wastes

4) Alternatives to incineration
   - The only component of the infectious waste stream which must be sterilized is pathological waste (e.g. body parts) and certain medications
   - For the infectious waste which remains, alternatives to be explored include
Forces For Change
In some states, it is the law which is driving hospital waste reduction programs. For example, in Wisconsin, medical facilities generating more than 50 pounds of medical waste per month must set goals for reducing waste, and prepare a waste reduction plan which is updated every five years. In New Jersey, hospitals were required to reduce their waste 40 percent by December 1, 1995. In Boston, the Massachusetts Water Resources Authority's strict mercury discharge standard prompted hospitals to initiate a collaborative effort to find alternatives for products containing mercury. On the state and federal level, the proposed MWI regulations will likely drive waste reduction efforts by making waste disposal through incineration more costly.

Waste reduction efforts at individual hospitals are usually driven by personal interest. Hollie Shaner, a nurse at the Fletcher Allen Medical Center, in Burlington, Vermont, was the driving force behind the hospital's landmark recycling program; she describes a trash-filled walk on the beach as the inspiration for her efforts. At Boston's New England Medical Center (NEMC), the vice-president for support services read an article in the local newspaper about airborne mercury pollution; a quick call to the environmental health department led to a light bulb recycling program three weeks later.

Reduce
The best opportunities to prevent pollution and waste are during the process of deciding what to buy. Reduction strategies entail eliminating unnecessary use of materials, such as packaging and supplies, as well as reducing or eliminating the use of toxic materials and chemicals. Reduction strategies not only cut down waste, they reduce the environmental hazards associated with the production, transportation, and use of products, such as energy and toxins use in manufacturing. Reduction strategies can also save money, by lowering purchasing and disposal costs.

Unneeded Products
Healthcare facilities can reduce waste by reducing unnecessary product use. For example, hospitals can eliminate unneeded products in standardized kits. Legacy Health System, of Portland, Oregon, pared down the contents of its custom procedure packs. The result has been the prevention of 11,000 pounds of waste, and savings of more than $30,400 per year. Patient admission kits (containing toiletries, etc.) or elements of kits can be purchased which meet the real needs of patients, or are relevant for their lengths of stay, rather than "one size fits all."

Packaging
Healthcare facilities can cut down on unnecessary packaging; they can also require vendors to use recyclable, or reusable packaging produced from recycled materials, and to eliminate PVC. Johnson & Johnson has designed a refill pack for its hospital first aid kits, saving the expense of buying a new container. Kendall Healthcare Products, of Mansfield, Massachusetts, has designed
a reusable corrugated shipper for a medical device it makes. The shipper is reused when the
device is sent back for servicing, helping ensure it is adequately protected.

Some hospitals have taken the lead in instructing vendors to reduce their packaging. St. Mary's
Hospital, in Wisconsin, told one vendor that they would switch to another if they were not
supplied with recyclable containers. Boston's NEMC has sent notices to suppliers requesting that
they cut down on packaging. One hospital consultant suggests placing requirements in contracts
for specific waste reduction goals.

Mercury
Within the spectrum of materials used by healthcare facilities, there are some which have been
targeted for reduction or elimination by government regulators and environmentalists. These
include toxic heavy metals, such as mercury, cadmium, and lead, and polyvinyl chloride, the
plastic known as PVC.

There has been much more regulatory focus on mercury, hence, substitution efforts in this area
are far more advanced. Mercury can be reduced by switching from mercury to digital electronic
thermometers; from mercury blood pressure monitoring devices to aneroid or digital devices; and
from mercury batteries to NI-CAD rechargeables. Boston's NEMC, for example, does not use
mercury thermometers, except for extremely infectious patients (when they are used only once).

Polyvinyl Chloride (PVC)
As increasing attention is focused on dioxin emissions from MWIs, current regulatory efforts are
being directed towards controlling emissions, rather than reducing the precursors to such
emissions. As outlined in chapter two, PVC is a major contributor to dioxin emissions from
MWIs.

Healthcare institutions use -- and dispose of -- far greater quantities of PVC than households or
other institutions. Hospital red-bag waste contains an estimated 9.4-15 percent PVC;
non-red-bag hospital wastes are as much as 10-15 percent PVC. PVC can be found in a variety of
medical products and applications, though most of the PVC content of medical waste is
accounted for by gloves and IV bags. According to one analysis for the City of New York,
PVC gloves and IV bags alone account for a substantial amount of the chlorine content of medical
waste.

Among the sources of PVC in medical products are the following:

Respiratory therapy products
- Ventilator tubing and hoses
- Oxygen therapy tubing (such as nasal prongs, oxygen tubing and masks,
  and rebreather masks)
- Endotrachial tubes
- Resuscitation bags or ambulance bags
- Face masks
- Oral airways

**Intravenous therapy**
- Solution bags
- Intravenous tubing
- Blood bags for transfusions
- Blood administration tubing

**Medication administration**
- IV bags and tubing for antibiotic therapy, chemotherapy, and other medications administered intravenously

**Kidney (renal disease) therapy**
- Peritoneal dialysis tubing and bags
- Hemodialysis tubing

**Other patient care products**
- Patient identification bracelets
- Nameplate cards
- Protective covers for x-rays and other medical images
- Notebook binders and plastic dividers in patient charts
- Blister packaging used to package DAVOL products (primarily urology products)
- Pillowcase covers
- Mattress coverings

**Anti-embolic therapy**
- Venodyne (this is the brand-name) anti-embolic stockings

Alternatives currently exist for many, if not all, of these products. According to one report, several European hospitals have virtually eliminated their use of PVC-containing products. One company, McGaw, manufactures a non-PVC IV bag which is being used by the Department of Veterans Administration. In addition to McGaw, there are at least nine other companies preparing to market or researching alternatives to PVC for IV bags and tubing. Alternatives to PVC are also available for disposable respiratory products, compression sleeves, patient identification bands, patient identification cards, packaging, and thermal blankets.

**Toxic Chemicals**
Another target for use reduction efforts is toxic chemicals and hazardous materials. Medical facilities use these for a range of diagnostic and treatment purposes. These substances include formaldehyde, solvents, radionuclides, photographic chemicals, waste anesthetic gases, and chemotherapy and antineoplastic chemicals. A guide published by the EPA discusses use and
waste reduction options for these substances. For example, formaldehyde is used, among other things, for disinfecting dialysis machines. According to the EPA, installing reverse osmosis water supply equipment helps reduce the need for cleaning and, hence, the use of formaldehyde.

Reuse
Disposables have replaced many of the products that were once washed, disinfected, or sterilized. However, the reusable options still exist, and some hospitals are seeing that they can be a sound choice:

- One hospital saved over $100,000 a year by returning to reusable scrub suits and gowns in the operating room.
- In one hospital in Australia, a survey found that all but 25 of the 500 paper towel dispensers could be replaced with washables towels or hot air dryers.
- Many hospitals are now buying mattresses with built-in egg crate foam pads rather than buying disposable foam underlays for patients.
- At Boston's NEMC, sharps containers are sent to a company in New York to be sterilized and then shipped back for reuse.
- New York's Beth Israel Medical Center has switched from disposable to reusable food service plates, silverware, trays, examination gowns, and bed underpads.

Other disposable products for which there are reusable alternatives include:

- Bedpans and urinals
- Cover gowns
- Resuscitation bags
- Blood pressure cuffs
- Diapers and briefs
- Thermal blankets
- Operating room gowns and packs
- Pillows
- Suture removal sets
- Temperature therapy pads
- Underpads
- Ventilator circuitry
- Washcloths
- Laser printer cartridges
Recycle
Successful recycling within healthcare facilities requires, first, a program to properly segregate materials, reducing the amount of waste being unnecessarily thrown into "red bags" as infectious waste. The amount of infectious waste generated by a typical hospital is only 3-15 percent of the hospital's total waste stream, depending on the definition of medical waste used (42 of the 50 states have different definitions for medical waste). Yet, as discussed in chapter four, many hospitals "red-bag" far more than this. In one hospital, office paper from the CEO's office was being red-bagged!

Such practices may appear economical for hospitals with their own incinerators. However, with the looming closure of many on-site MWIs, and diversion of waste to regional MWIs, unnecessary red-bagging constitutes little more than burning money. New York's Beth Israel Medical Center is saving over $600,000 by reducing unnecessary red-bagging. In addition, the disposal of office paper, cardboard, and other materials in red-bags presents an insurmountable obstacle to recycling; not even the most avid recycler would retrieve an aluminum can from a red bag.

Fletcher Allen Healthcare, in Burlington, Vermont, has been a standard-bearer in hospital recycling efforts. As of 1994, Fletcher Allen was recycling 21 different materials, including construction and demolition debris, phone books, x-ray film, and kitchen grease. Fletcher Allen has been recycling solvents such as xylene, ethanol, and toluene since 1990. The solvent recycling unit paid for itself in three years. Food waste is composted at a nearby organic farm, which supplies the hospital with fresh vegetables. By January 1994, the facility had a 34 percent recycling rate. In Boston, the NEMC's recycling program includes mercury lighting tubes; batteries; solvents; and "lead pigs" used for carrying radioactive materials. The NEMC also "recycles" excess laboratory glassware to staff who need them. In addition, the NEMC is setting up a program to recycle scrap metal (copper and steel) from construction.

The key elements to successful recycling efforts can be called the "Two E's" -- education and ease. At Fletcher Allen, recycling programs are covered in the employee handbook. The hospital also uses posters, newsletters, a 24-hour hotline, and an on-line recycling manual. Recycling bins are placed in each of the hospital's 13 operating rooms. Cardboard recycling is maximized by uncrating everything at the distribution center and recycling the cardboard there.

A unique recycling program has been initiated at the Yale University School of Medicine in New Haven, Connecticut. Researchers there calculate that American hospitals throw away 2,000 tons, or $200 million worth of unused surgical supplies every year. The school has set up a program to channel its unused supplies to a hospital in Nicaragua. About 60 hospitals now follow the system set up by Yale.

Alternatives to Incineration
When the inventory of "reduce, reuse, recycle" options have been exhausted, alternatives to
medical waste incinerators for treating what remains should be explored. Three alternatives to incineration are currently being used in a number of North American and European hospitals and off-site facilities.

These are:

1) Autoclaving (steam sterilization) and shredding;
2) Shredding, followed by chemical disinfection; and,
3) Shredding, followed by microwaving.

It is important note that these are not waste disposal technologies -- waste that has been autoclaved, disinfected, or microwaved will also be disposed of in either a landfill or municipal solid waste incinerator.

Before widespread adoption of these or other alternatives occur, however, a thorough examination should be made any potential environmental or workplace risks.

There are, in fact, known hazards associated with autoclaves. According to the EPA, some autoclaves emit organic compounds like chloroform, formaldehyde, and acetaldehyde. There is also the potential for mercury emissions from autoclaves. Under section 112 of the Clean Air Act, the EPA can regulate facilities such as autoclaves which emit toxic substances.

Another concern is that the medical waste disposal industry appears to be attracting "fly-by-night" entrepreneurs. According to one consultant, only a single alternative treatment process was commercially available for treating medical waste in 1988. By 1991, 18 different alternatives were available or being developed. By 1993, ten of the companies offering these alternatives were out of business.\(^{81}\)

\(^{81}\)
Chapter 4

Barriers to Change

Significant barriers interfere with the reform of materials use and disposal practices in hospitals and other healthcare institutions. When they are successfully overcome, the volume and toxicity of waste is substantially reduced. As might be expected, materials purchasing, use, and disposal practices reflect a combination of institutional characteristics, real and perceived health risks, and the current understanding of product toxicity. Moreover, in an industry which is already undergoing complete restructuring, there is resistance to yet more change.

Institutional and Economic Barriers

An industry in flux

Organizational structure and function, as well as the current climate in healthcare institutions, help determine purchasing and waste disposal practices. Mergers, downsizing, managed care, increasing competition, shifts to outpatient care, and Medicare reform all interact to force rapid, unprecedented change in this large sector of the economy. These changes are disruptive for patients, practitioners, administrators, staff, and communities. Along with large shifts in capital and power, a climate of uncertainty and stressful new relationships foster a general resistance to further change.

It is not an environment that favors education and behavior change surrounding a new, and for the hospital administrator, insignificant issue. But this is exactly what is required to fundamentally alter the nature and disposal of healthcare facility waste. Moreover, restructuring has sharply focused attention on hospital-specific economic performance as a major motivator and goal. Any proposed institutional change must squarely address that cost-efficiency challenge.

Group purchasing

Hospitals are often organizationally structured in ways that make changes in product purchasing difficult to justify or implement. Of the approximately 6,000 hospitals in the United States, all but a few belong to group purchasing organizations (GPOs). Many are large with statewide, regional, or even nationwide membership. While participation in a GPO confers financial benefits through economies of scale and price-bargaining strengths, individual member institutions lose some decision-making authority and are often tied into long-term contracts with restricted options. Contractual arrangements with a supplier of a diverse medical-product line may preclude purchase of an environmentally-preferable, cost-competitive item from another supplier with fewer available products. On the other hand, GPOs also offer an opportunity for large influences on medical waste through the collective impact of purchasing decisions on manufacturers. As customers, GPOs are in a position to drive the market toward product production and use which is sensitive to worker safety, public health, and environmental concerns.
Bureaucratic separation of purchasing and disposal

Purchasing decisions are usually based on product cost, availability, and performance. Since disposal costs or external health and environmental impacts are not among these criteria, they are rarely considered unless regulatory compliance is at stake. Moreover, as a whole, waste disposal costs represent only a small fraction of an institutional operating budget. For example, in one moderately sized medical center in New England, waste disposal costs are only about 0.2 percent of the total budget. It is, therefore, not a budget item which receives much attention, and it is not unusual for no one to know waste disposal costs with certainty.

Purchasing and disposal decisions are ordinarily made through different organizational pathways -- and because there are virtually no incentives for considering disposal costs in purchasing decisions, they rarely are. Moreover, the common practice of allocating all institutional waste disposal costs to one department, such as housekeeping, further serves to isolate them from purchasing and use decisions. A supervisor will usually be able to identify quickly the cost of departmental supplies but will rarely have any idea of the cost of their disposal because it is not in the departmental budget.

Furthermore, at the institutional level, purchasers often believe it is cheaper to buy a disposable item, use it once, and discard it than to wash, sterilize, and repackage a reusable, all of which require staff, space, and resources. This cost-saving may appear even larger if the item is made by low-wage overseas workers. Of course this level of analysis fails to account for all costs of resource extraction, production, and disposal including health and environmental impacts.

Waste disposal practices may differ among departments. In one large metropolitan teaching hospital, two intensive-care nurses working in separate departments described very different waste-handling educational programs and practices. One department has regularly-scheduled refreshers on departmental policy with required staff attendance. The other rarely schedules them and asks only that staff sign a paper periodically stating that they have received instruction -- whether they have or not.

Growth of outpatient care

Although most waste-producing healthcare has historically been delivered in hospitals, there is now increasing emphasis on care provided in non-hospital settings. Home healthcare providers generating increasing volumes of waste have more disposal options than those within institutional walls. Used IV bags, tubing, packaging, and devices may be discarded in household trash, handled by unprotected waste haulers, and sent to landfills or municipal waste incinerators. Policies or initiatives which address only the handling of hospital waste rather than product purchase, use, and disposal in all healthcare settings will fail to address these increasingly significant sources.

Real and Perceived Risks of Disease

Within the past 15 years there have been major shifts in material-handling practices and the
treatment of patients with, or susceptible to, infectious disease. These changes have occurred, in part, because of the emergence of the HIV epidemic and fear of the transmission of this and other infectious diseases. Other motivations include concern for patients with impaired immune systems, hazardous work-related exposures for hospital staff, and highly-publicized incidents of medical waste washing up on beaches or found in trash cans in the late 1980s. Intense public pressure has contributed to a variety of state and federal regulations which vary remarkably in their definitions of medical waste and prescribed handling practices.

The concept of "universal precautions" requires that all body fluids be regarded as potentially infectious. Such a sweeping definition encourages the generation of massive amounts of what is believed to be "infectious waste", unjustified on closer examination of real data. "Red-bagging" is the practice of discarding "contaminated" waste in red bags earmarked for disposal as regulated medical waste -- often in medical waste incinerators. Without a clear understanding of what truly belongs in that category, "red-bagging" has been overused in most institutions, as demonstrated by detailed analyses of bag contents.82 Surveys of hospitals show that some actually encourage the disposal of all waste from patient care areas in red bags while others attempt to be more selective but with little monitoring or education.

States differ substantially in their definition of "regulated waste." Varying definitions of "blood and blood products" alone can make enormous differences in the volume of segregated waste.83 But operating room surveys find that frequently more than half of the red bag waste is generated before the patient enters the room -- before there is any possibility of contamination by infectious body fluids. Moreover, the Centers for Disease Control (CDC) agrees that no epidemiologic evidence exists to indicate that hospital infectious wastes need to be treated differently than other solid wastes, yet recommends red bag collection and special disposal.84 Though the reasons for the recommendation are evident, in practice, red bags are often used indiscriminately. Studies actually show that household waste is far more contaminated with bacteria than hospital waste,85 and with increasing emphasis on outpatient and home healthcare, household waste often contains medical-use products as well as body fluids. Hospital surveys show that 1.5-2.5 pounds of red bag waste per day for each bed actually occupied is a reasonable expectation and justifiable under the varying definitions of regulated waste. Yet 2.5-3.5 pounds per day per bed occupied is common and more than four pounds per day is sometimes seen.86 There is, therefore, considerable opportunity for substantial red-bag volume reduction without putting staff or waste haulers at risk or violating regulations.

Staff Resistance to Change
Waste segregation, essential for successful recycling efforts and widely practiced with household waste, is perhaps the most important first step in reducing the volume and toxicity of the medical waste stream. Paper products, some plastics, and metals can readily be recycled in existing markets. Medical-use PVC can be reprocessed into other PVC products, though they, in turn, usually find their way to a landfill or municipal waste incinerator representing little net advantage with respect to the hazards of PVC.
Waste segregation requires commitment and education, though not much in the way of additional time if systems are properly designed. For example, strategically locating red bags in areas only where necessary and liberally offering non-red-bag options where possible will substantially reduce red-bag volume. But professional and institutional staff who are not historically waste conscious and who are not accustomed to thinking of the public health impacts of their practices are not likely to voluntarily modify them without education, persuasion, and even perhaps, a regulatory stick. Hospital administrators may find some public relations value to portraying their institutions as "green" with respect to waste disposal, but, in the end, economic considerations carry considerable weight. For that reason the economic advantages of waste reduction, reuse, and recycling deserve close attention. There are many examples of institutions which have saved considerably by product purchasing and disposal modifications, including reducing, reusing, and recycling.

Science and Product Information Gaps

MWIs emit dioxins, toxic metals, and other harmful substances directly into the environment and produce contaminated ash which requires disposal. Ash is deposited in landfills where leaching of soluble metal salts may add to the downstream toxicity of medical waste incineration. There is no general agreement about the precise amount of dioxin generated by MWIs, but the range of estimates continues to place medical waste incinerators among the leading sources.

Many researchers, attempting to understand how dioxin is created in MWIs, conclude that an important source of chlorine necessary for dioxin formation is chlorinated plastics -- in particular, PVC. Incinerator design and operating conditions are also important variables. Most analysts generally agree that dioxin formation results from combinations of these factors. There is disagreement about the relative importance of each, and various special-interest groups have capitalized on the disagreement by putting their own political spin on the science. An editorial in *Pharmaceutical and Medical Packaging* concludes that PVC dodged a bullet when the American Medical Association (AMA) decided to collect further information before adopting a position on PVC in the medical waste stream. The AMA is currently collecting information on mechanisms of dioxin formation and the contribution of various forms of chlorine before adopting a formal position. And the American Hospital Association lobbying voice now claims that cash-strapped hospitals no longer have to worry -- that incinerators are no longer the threat that they were perceived to be.

Finally, institutional staff responsible for purchasing products are often hard pressed to find information about product or packaging components. There is no centralized database which could help inform individuals or organizations interested in purchasing products with minimal environmental impact.

Varying estimates of toxic MWI emissions, lack of consensus around the magnitude of health risks attributable to dioxin and other contaminants, and political pressure from industrial interest groups influence medical facility administrators' response to concerns about material production, use, and disposal. These factors, along with the changing climate in the healthcare industry, make...
behavior changes more difficult to achieve. Nevertheless, the volume and toxicity of medical facility waste could be reduced significantly. As currently managed, there is substantial and unnecessary environmental contamination. The ethical obligation of the healthcare industry to explore all opportunities to reduce waste generation and to reuse and recycle in safe and appropriate ways is clear. Rather than simply waiting to respond to government regulation, the industry could seize this as an opportunity for public health leadership.
Policy Recommendations

The policy recommendations that follow are based on the information and concerns raised in this report, including the following findings:

1) The disposal of healthcare facility waste in medical waste incinerators (MWIs) is a major source of toxic pollution, including dioxin and mercury.
2) In addition to disposal impacts, the production, transportation, and use of products results in the consumption of energy, toxic feedstocks, and natural resources, contributing to environmental degradation and pollution.
3) Only 15% or less of all medical waste needs to be treated as infectious and sterilized (one possible means being incineration). Hospitals routinely burn 75-100% of their waste.
4) Current and proposed regulatory programs and policies, at both the state and federal level, fail to protect public health from the threat of incineration.

Underlying these recommendations is the belief that the credo, "Do no harm," dictates a responsibility by healthcare providers and healthcare facilities to examine, reduce, and, where possible, eliminate any negative impacts to public health and the environment due to their purchasing, operating, and waste management practices.

General goals of the following policy recommendations are:

1) Reduce the volume and toxicity of the healthcare facility waste stream through adoption of the "reduce, reuse, recycle" model.
2) Encourage a focus on product purchasing, including an examination of the environmental impacts of products throughout the lifetime of their production, transportation, use and disposal.
3) Reduce the volume of materials incinerated.
4) Eliminate the incineration of mercury-containing products and chlorinated plastics (such as PVC).
5) Encourage the examination of alternatives to incineration.

Our policy recommendations are directed at three audiences: individual healthcare facilities and institutions, accreditation organizations, and the Maryland Department of the Environment.

I. Healthcare Facilities and Institutions
These recommendations apply to any and all hospitals (large, medium, and small), clinics, medical offices, and outpatient facilities. The recommendations involve and require training for the entire range of healthcare facility staff, from administrators to healthcare providers to purchasing agents. This is because the entire staff is involved in the key decisions which affect medical waste, including what to buy and how to dispose of it. It should also be stressed that group purchasing
organizations (GPOs) should be used as a positive force for change, leveraging their buying power to demand "green products."

Recommendations include:

A. Conduct comprehensive waste audits, examining:
   1) The quantities and types of waste materials being generated in each department.
   2) The amount of "red bag" waste being generated in each department.
   3) The means of disposal used, the cost, and the public health and environmental impacts.

B. Assign waste disposal costs to each department, instead of aggregating and paying them out of one budget.

C. Reduce.
   1) Identify products containing mercury, determine if substitutes are available, assess whether they meet specifications, and begin purchasing them.
   2) Identify products containing polyvinyl chloride (PVC), determine if substitutes are available, assess whether they meet specifications, and begin purchasing them.
   3) Eliminate unnecessary product use.
   4) Purchase products made from recycled materials.
   5) Avoid unnecessary packaging and packaging made from PVC.

D. Reuse.
   1) Identify disposable products which could be replaced by reusable versions and begin replacing them.

E. Recycle.
   1) Institute initiatives to reduce red-bag waste, to both save money and increase the volume of materials which can be recycled.
   2) Maximize the quantity and types of materials being recycled -- from the conventional (office paper, newspapers, glass, aluminum, and steel) to the unconventional (light bulbs and construction debris).

II. Accreditation Organizations
All accreditation organizations should require healthcare facilities to implement materials use policies designed to reduce the volume and toxicity of the medical waste stream.

III. Maryland Department of the Environment
The Maryland Department of the Environment's proposed regulations do not meet the criteria established by the Clean Air Act. If this is to be remedied, the following recommendations should be taken into account:
A. Set stronger emission limits
1) Require the maximum achievable control technology (MACT) as required by the Clean Air Act.
2) Include limits for arsenic, chromium, nickel, and PCBs.
3) Hold small rural incinerators to the same emissions standards as other incinerators.
4) Require all incinerators to implement the new standards by March, 2001.

B. Require waste segregation
1) Require operators to develop plans which contain detailed strategies for reducing the volume and toxicity of the waste stream.
2) Mandate the implementation of waste management plans.
3) Provide guidance on alternative approaches to meeting emission limits, such as waste segregation for mercury-containing and PVC materials in MDE’s Technical Support Document for Hospital Medical Infectious Waste Incinerators.
4) Include waste prevention as a component of incinerator operator training.
5) Require operators of commercial MWIs to hold waste prevention trainings for clients.

C. Strengthen testing and inspection
1) Require continuous emissions monitoring for carbon dioxide, hydrogen chloride, sulphur dioxide, nitrogen oxide and oxygen.
2) Take into account the frequency of startups and shutdowns when permitting and monitoring incinerators.
3) Prohibit the averaging of test runs -- one failure should constitute failing the test.
4) Publish stack test results in the newspapers of the communities who host the MWIs.

In addition, MDE’s Office of Technical Assistance should conduct research and provide technical assistance to healthcare facilities to help them reduce the volume and toxicity of their waste streams.
### Appendix A: Medical Waste Incinerators in Maryland

*(MDE Estimates of Uncontrolled Emissions from Medical Waste Incinerators)*

<table>
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<tr>
<th>Name and Location</th>
<th>Capacity Lbs./ Hr.</th>
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<th>Lbs. Burned/ Day</th>
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** Taking into account the actual amount of medical waste burned and existing pollution control devices, MDE staff estimate that Maryland medical waste incinerators release a total of 968 pounds of mercury a year. They did not break down this data by facility.
**Appendix B: Dioxin and Mercury Pollution Standards vs Phoenix Services, Inc. Emissions Stack Test Results**

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** National Resources Defense Council (NRDC) staff scientists calculated emissions standards, based on Maximum Achievable Control Technology, as mandated by the Clean Air Act. These estimates are much more strict than MDE’s proposed standards, which were handed down by the U.S. EPA.
Endnotes


6. Personal conversation with employees of Maryland Department of the Environment’s Air and Radiation Department.


15. Current Medical Waste Incinerator Regulations, Maryland Department of the Environment, Title 26, Subtitle 11 Air Quality, Chapter 8, Control of Incinerators.


41. Luster MI, Boorman GA, Dean JH. Examination of bone marrow, immunologic parameters, and host susceptibility following pre- and post-natal exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Int J Immunopharmacol 2:301-310, 1980.


60


70. Ibid.


74. Ibid.

76. Ibid.

77. Personal communication, Hollie Shaner, CGH Environmental, Inc. August 13, 1996.


86. Personal communication - Hollie Shaner RN.


