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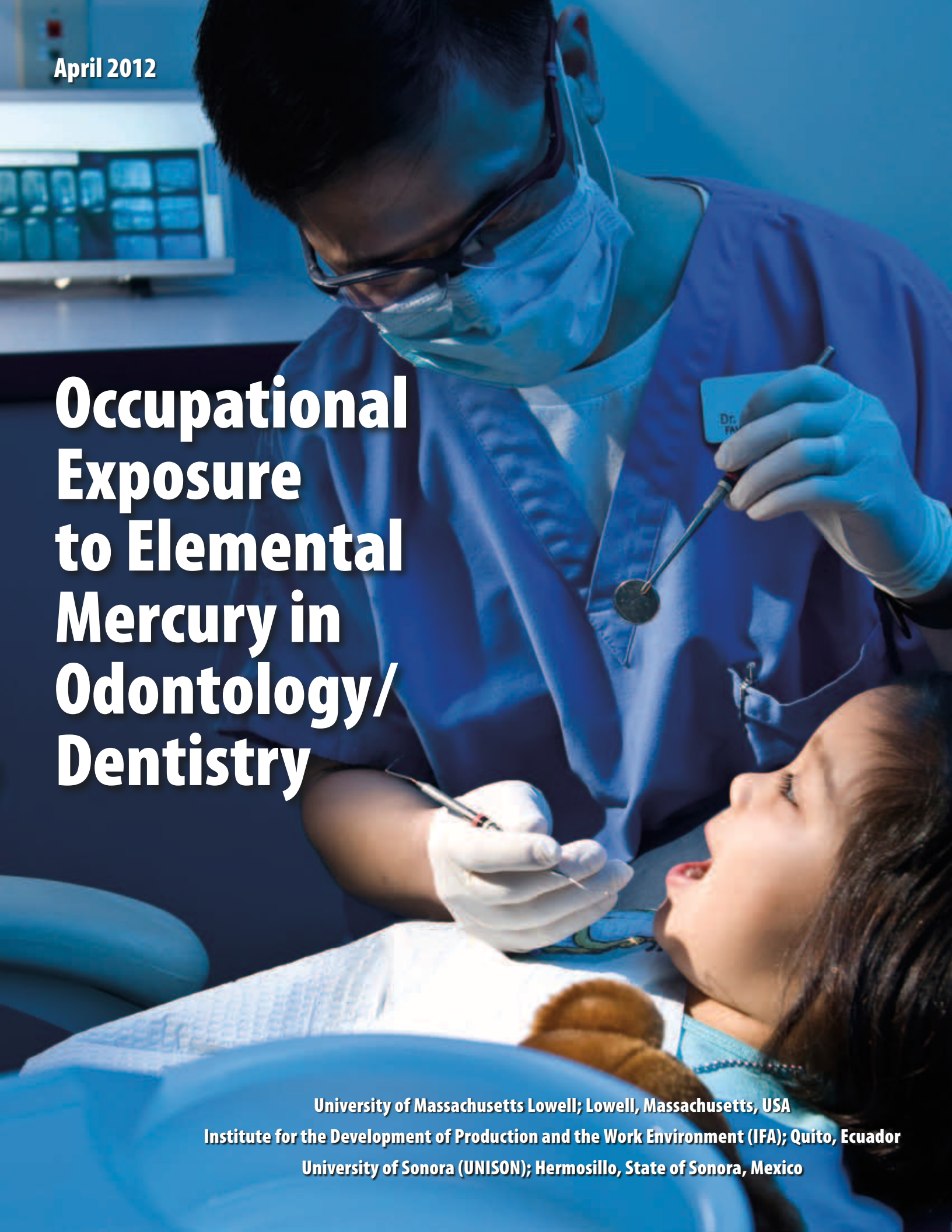
Occupational Exposure to Elemental Mercury in Odontology/ Dentistry



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About the Lowell Center

The Lowell Center for Sustainable Production is a research center of the University of Massachusetts Lowell working to build healthy work environments, thriving communities, and viable businesses that support a more sustainable world. We do this by working collaboratively with citizens' groups, workers, businesses, and government agencies.

Executive Summary

Mercury is recognized as harmful to human health and the environment. It is highly toxic to humans and may harm vital organ systems, including the nervous, digestive, respiratory, renal, and immune systems. As a result, international efforts are underway to eliminate the use of products with intentionally added mercury.

This report reviews the literature, describes the use of mercury in odontology, and raises issues of concern for human health. In odontology and dental clinics,[1] mercury may be found in dental amalgam and measuring devices such as thermometers and blood pressure cuffs (sphygmomanometers, tensiometers). Studies have shown elevated concentrations of mercury in the ambient air in dental settings. This mercury vapor may enter the body through inhalation and be transported to different organs throughout the body where it can accumulate.

This report recommends developing a program to minimize the use of mercury, lessen the potential for exposure, and control mercury waste. This will benefit dental workers by decreasing their exposure to this toxic material and will reduce environmental impacts from mercury in solid waste, in the air, and in wastewater.

Findings

Mercury exists in several forms:

Elemental mercury, used in dentistry, has no electrical charge (Hg^0)
Inorganic mercury has a positive charge of +1 or +2 (Hg^{1+}, Hg^{2+})
Organic mercury is a complex of mercury with carbon-containing compounds

Both the charge and the chemical form affect the absorption, transport, and impact of mercury in the body.

The silvery liquid elemental mercury, also called metallic mercury, is used in dental amalgams (Baelum and Pockel, 2007; WHO, 2003). Elemental mercury toxicity is usually a result of exposure to vaporized mercury that enters the body through inhalation. Brief exposures to a high concentration can result in toxicity to the lungs, including chest pain, bronchitis, and pneumonitis. Three signs of exposure to high concentrations are excitability (erethism), tremors, and gingivitis (MA DEP, 2011).

Poisoning from inhaled mercury can also result from chronic exposure at lower air concentrations. This is the exposure of most concern for health care workers in odontology. The nervous system is very sensitive to mercury and permanent damage can occur from chronic exposure to inhaled metallic mercury, which is transported in the blood and crosses into the brain where it can cause permanent damage. Health effects may include personality changes, tremors, vision changes, muscle incoordination, loss of sensation, difficulty with memory, and deafness (US DHHS, 1999; US DHHS ATSDR, 1999; WHO, 2003).

1 Depending on geographic location, the term "dentistry" or "odontology" may be used to describe the branch of medicine dealing with the anatomy and development of diseases of the teeth. In this report the terms are used interchangeably.

Inhaled elemental mercury can accumulate in the kidneys and damage sensitive kidney tissue (US DHHS ATSDR, 1999). Long-term low-level exposures may result in damage to the lining of the mouth and lungs (MA DEP, 2011).

Exposure to elemental mercury is of particular concern to nursing or pregnant workers. Women who breathe contaminated air can pass elemental mercury into a developing baby via the placenta or breast feeding. These exposures have been associated with developmental delays and attention deficit disorders in childhood (WHO, 2005).

Studies show that clinics using mercury have elevated levels of mercury vapor in the work environment. This report shows that dental health care practitioners are routinely exposed and carry a higher body burden of mercury than the general population. Workers' body levels of mercury reflect their workplace practices including work tasks and frequency, types of equipment and processes, and workplace hygiene (Ritchie, 2004). Significant correlations have been found between body concentrations and work areas that have high mercury levels in the breathing zone, such as the amalgam preparation, autoclave, and amalgam storage areas. For dentists, the number of fillings placed or removed per week and the number of hours worked in the clinic was found to be related to their body level of mercury (Ritchie, 2004).

In many countries mercury exposures in odontology have been decreasing over the past decades. This is attributed to increased awareness and education, improved equipment and work controls, use of non-mercury restoration materials, and more rigorous occupational regulations (Ritchie, 2002). Increased patient awareness also plays a crucial role with patients asking that safer materials be used. Unfortunately, these improvements have not been incorporated universally and many dental health care workers are still exposed to mercury levels causing health risks (UNEP, 2002).

Recommendations

Minimizing, and ultimately eliminating, exposure to mercury in odontology is a precautionary approach that will reduce cumulative exposure to dental health care workers and prevent its transport to downstream ecosystems (Tickner, 2006).

1. **Dental clinics should exercise precaution through the thoughtful choice of products and practices.** Eliminating use of mercury where feasible, using engineering controls, improving systems of work, and use of personal protective equipment will all serve to reduce worker exposure to mercury. These are important first steps.

2. **Governments and stakeholders (such as professional organizations, environmental groups, healthcare providers,and insurance companies) should act to make safe control and elimination of mercury economically, technically, and logistically feasible.** Actions such as restrictions on the procurement, transportation, and use of mercury as well as fostering a means for safe mercury disposal, will provide a driving force for widespread improvements at the level of the dental clinics.

Reducing occupational exposure to elemental mercury in odontology and dentistry is a challenge, but solutions are within reach. No single step will be sufficient, but efforts at multiple levels—within clinics and at high levels of government and stakeholder organizations—will bring about the improvements that will protect the health of odontology workers and will reduce the impact of mercury in the environment.

Background

Mercury is highly toxic and may cause harmful effects to vital organ systems including the nervous, digestive, respiratory, renal, and immune systems. As a result, there is a large international effort by medical personnel, non-governmental agencies (e.g. WHO, UNEP), and governments to reduce both the use of and exposure to mercury in healthcare settings. In dentistry, the exposure of concern is elemental mercury (Hg^0), the very volatile silvery liquid used to make amalgam for filling cavities.

Approximately 80% of inhaled elemental mercury vapor is absorbed by the lungs and is circulated to organ systems (WHO, 2003). The effects of long-term chronic exposure may manifest in many ways including: tremors, impaired vision, impaired hearing, paralysis, difficulty sleeping, emotional instability, developmental deficits for fetuses, and developmental delays and attention deficit issues in childhood (WHO, 2005).

The purpose of this paper is two-fold:

1. Properly educate odontologists to reduce the use of and carefully control elemental mercury, including containment, clean up, and disposal practices.

2. Call for public health action by governments and stakeholder organizations that make elimination and control of mercury economical and technically and logistically feasible.

Health Effects of Mercury

This section describes the different forms of mercury and the health effects of elemental mercury exposure (the form used in dentistry). These effects highlight the need to reduce and eliminate the use of mercury whenever possible.

Mercury can exist in several forms.

Elemental or metallic mercury (often written as Hg^0) is used in amalgam, in measuring devices such as blood pressure cuffs (tensiometers) and thermometers, and in electrical devices. It readily vaporizes and has no electrical charge.

Inorganic mercury is positively charged at a level of either +1 or +2. It is found in salts that have been used in catalysts, paints, topical disinfectants, and preservatives in medical preparations.

Organic mercury is a complex of mercury with carbon-containing compounds. Although there are a number of sources of exposure, the primary source for most humans is consumption of methyl-mercury-contaminated fish (MA DEP, 2011).

Each of these forms of mercury is highly toxic. They accumulate in the body tissues and environment where they remain for long periods of time.

(MA DEP, 2011)

Mercury in all three forms is highly toxic and accumulates in both body tissues and the environment, where it remains for long periods of time (MA DEP, 2011).

Route of entry, as well as the charge and chemical form of mercury affect how it is absorbed and transported in the human body. Uncharged mercury can move into cells readily. Mercury that has a charge is largely prevented from passing across barrier membranes such as the blood-brain barrier and the placenta, unless it is carried through as part of another molecule. The distribution and toxicity of mercury in the body are complex since each of the three chemical forms, under the right circumstances, can be changed to one of the other forms. In the body, conversion to the charged, inorganic form predominates but other transformations can also occur (MA DEP, 2011).

Transport and Toxicity of Elemental Mercury

Elemental mercury toxicity is usually a result of exposure to the vaporized form (WHO, 2003). Even a brief exposure to a high concentrations, can result in toxicity to the lung, including chest pain, bronchitis, and pneumonitis. Three signs of exposure to a high concentration of mercury in air are excitability (erethism), tremors, and gingivitis.

At lower air concentration there may be no early signs of toxic effects because the vaporized mercury is cleared from the lungs to the blood or by exhaling. Poisoning from inhaled metallic mercury can occur after chronic low-level exposure as the mercury is carried through the body and affects different organs and systems (MA DEP, 2011).

From the lungs, mercury moves through the body in the blood stream, in plasma and red blood cells. In plasma, mercury remains as Hg^0 and readily moves into the brain and placenta, where it is converted to Hg^{2+} and causes neurological damage. In red blood cells, mercury is oxidized to the Hg^{2+} form, which does not readily cross barrier membranes. Instead, it moves through to the kidneys where it collects (Timbrell, 1995).

The ***nervous system*** is very sensitive to mercury and permanent damage to the brain can occur from exposure to sufficiently high levels of metallic mercury. After crossing into the brain, mercury may affect many different areas of the brain and their associated function, resulting in a variety of symptoms. These include personality changes (irritability, shyness, and nervousness), tremors, changes in vision, deafness, muscle incoordination, loss of sensation, and difficulties with memory (US DHHS, 1999; US DHHS ATSDR,1999; WHO, 2003).

The nervous system is very sensitive to mercury and permanent damage to the brain can occur from exposure to sufficiently high levels of metallic mercury.

(US DHHS ATSDR, 1999)

The ***kidneys*** are also sensitive to the effects of mercury. Mercury accumulates in the kidneys, causing continuous high exposures to these tissues and therefore more damage. All forms of mercury can cause kidney damage if large enough amounts enter the body (US DHHS ATSDR, 1999).

Skin contact with metallic mercury has been shown to cause an allergic reaction (skin rashes) in some people (US DHHS ATSDR, 1999).

Exposure to lower levels of mercury vapor over longer periods of time can result in damage to the lining of the ***mouth and lungs*** (US DHHS ATSDR, 1999).

Second-Hand Exposures

Metallic mercury can be carried home on a worker's contaminated clothing and shoes. Exposure to mercury has been reported in children of workers who are exposed to mercury at work, and increased levels of mercury were measured in places where work clothes were stored and in some washing machines. The children most likely to be exposed to risky levels of mercury are those whose parents work in facilities that use mercury, but where no protective uniforms or footgear are used. In some reported cases in which children were exposed in this way, protective clothing was used in the workplace, but contaminated items were taken home, thus exposing family members (US DHHS ATSDR, 1999).

All forms of mercury can cause kidney damage if large enough amounts enter the body.

(US DHHS ATSDR, 1999)

The same harmful health effects seen in adults are also seen in children with similar mercury exposures (US DHHS ATSDR, 1999). Nursing or pregnant workers who breathe contaminated air can also pass elemental mercury into a developing baby. These exposures have been associated with developmental delays and attention deficit disorders in childhood (WHO, 2005).

Mercury Exposures in Dental Workers

Elemental mercury is a key ingredient in the dental amalgam used as a filling material for decayed or damaged teeth. Amalgam is an alloy comprising mercury (typically 45-55%), silver (approximately 30%), and other metals such as copper, tin, and zinc (WHO, 2005). Although other mercury-free options are now available, dental amalgams continue to be used worldwide because of familiarity, ease of use, durability, and favorable cost (CDC, 2009; UNEP, 2010).

Studies show that odontology and dental clinics that use mercury have elevated levels of mercury vapor in the work environment. Significant correlations have been found between dentists' body levels of mercury and workplace environmental mercury concentrations (Ritchie, 2004). Consequently, mercury in the ambient environment is of concern for dental practitioners.

Dentists, dental assistants, technicians, and other workers in the odontology or dental setting are exposed to mercury from a combination of amalgam-related tasks and workplace conditions, including:

- Bulk storage, such as vials or jars of elemental mercury
- Spills during handling of bulk mercury
- Preparation of amalgam
- Use of amalgam in new dental fillings, including finishing and polishing the amalgam surface
- Restoration of old fillings, including removing old amalgam
- Clean up of work areas and tools, including cleaning waste amalgam residues from surfaces and autoclaving of tools
- Accumulated residue in the work areas
- Disposal and storage of waste amalgam and mercury (Canto-Pereira, 2005; Ritchie, 2004; US FDA, 2009)

Routes of Exposure

In odontology the three primary routes of exposure to mercury include: 1) inhalation of mercury vapor or amalgam dust, 2) ingestion, and 3) dermal exposure.