

Medical Management Guidelines for Lead-Exposed Adults Revised 04/24/2007

Summary:

Overexposure to inorganic lead continues to be an important problem worldwide. The reduction of lead in the U.S. environment, largely accomplished through effective EPA regulatory efforts, has resulted in lowering the overall geometric mean whole blood lead level (BLL) for the general population in the United States from approximately 13 $\mu\text{g/dL}$ (0.63 $\mu\text{mol/L}$) in the 1970s to less than 2 $\mu\text{g/dL}$ (0.10 $\mu\text{mol/L}$) (CDC 2005; NCHS 1984). Lead exposure remains a significant public health and medical concern for thousands of children and adults exposed primarily through remaining lead-based paint in older housing stock as well as to workplace exposures, although other sources occur. For children and adults, the role of environmental investigation, identification and reduction or elimination of sources of exposure remains of primary importance. While the clinical care of lead-exposed children has been well established in the pediatric and public health communities, similar clinical recommendations for adults have not been widely available.

The purpose of this document is to provide useful advice to clinicians caring for adult patients who have been exposed to lead, whether at work, at home, through hobbies, in the community, through consumer products, retained bullets, or other sources. This document is derived, in part, from the input of an expert panel convened by the Association of Occupational and Environmental Clinics (AOEC). However, three clinical scholars then considered the medical evidence submitted by the expert panel and incorporated many of the conclusions reached by this panel. This paper, therefore, reflects a general consensus of the clinical views of AOEC members, not necessarily the expert panel, particularly in areas where the expert panel had been unable to come to consensus. The following points are emphasized:

- 1) Medical care serves as an adjunct to public health and industrial hygiene exposure control. Clinicians who evaluate patients with potential lead exposure should have appropriate referral mechanisms in place for prevention of further exposure to lead. Although one goal of health care is to remove the patient from exposure, the social consequences of potential disruption of housing or of income may be important and must be considered by the clinician.
- 2) Current occupational standards are not sufficiently protective and should be strengthened. Although the federal Occupational Safety and Health Administration's (OSHA) lead standards have provided guidance that has been beneficial for lead-exposed workers, these regulations have not been substantially changed since the late 1970s and thus are primarily based on health effects studies that are well over three decades old. There is an urgent need to revise them.
- 3) The clinical guidelines presented here are appropriate for adults, recognizing that younger adults, particularly those in workplace settings, may share developmental risks that place them closer to pediatric populations, and that maternal exposure, whether in the workplace or in the general environment, places the developing fetus at risk for exposure.

4) Clinicians should feel free to contact any of the member AOEC clinics for additional telephone advice, and are encouraged to refer patients when appropriate.

Background

Lead is used in over 100 industries. Job activities known to involve the use or disturbance of lead include: handling of lead-containing powders, liquids, or pastes; production of dust or fumes by melting, burning, cutting, drilling, machining, sanding, scraping, grinding, polishing, etching, blasting, torching, or welding lead-containing solids; and dry sweeping of lead-containing dust and debris. Adults also encounter lead in environmental settings and through activities such as home remodeling, particularly in homes built before 1978 that contain lead-based paint, lead-contaminated consumer products, traditional remedies, moonshine whiskey, hobbies, such as melting lead sinkers or use of target ranges, from retained bullets, and through other sources.

Lead is not an essential element and serves no useful purpose in the body. A substantial body of recent research demonstrates that multiple health effects can occur at levels once considered safe. The routes of exposure for inorganic lead are inhalation and ingestion. Once absorbed, lead is found in all tissues, but eventually 90% or more of the body burden is accumulated (or redistributed) into bone with a biological half-life of years to decades. Lead is excreted primarily in the urine. Lead does not remain in the bone permanently but is slowly released back into the blood.

The “dose” or quantity of lead that a person receives will be determined by the concentration of lead in the air and/or the amount ingested as well as the duration of such exposure. The BLL remains the predominant biological marker used in clinical assessment, workplace monitoring, public health surveillance, and regulatory decisions regarding removal from exposure under the OSHA lead standards.

Research tools capable of measuring cumulative lead exposure, such as the use of in-vivo K-shell X-ray fluorescence (K-XRF) instruments for the rapid, non-invasive measurement of lead in bone, have expanded recent understanding of long-term consequences from lead exposure on a population basis. These studies have demonstrated adverse effects of lead exposure across populations, including on neurologic, reproductive and renal function and on blood pressure, that occur at extremely low levels of exposure and appear not to have a threshold. However, because inter-individual differences are greater than population differences at lower lead levels, these effects are less important for clinical evaluation than they are for public health policy. The preponderance of the evidence for adverse effects at levels of exposure far below those currently permitted by OSHA speaks forcefully for an immediate reduction in permissible exposure levels in the workplace and for enhanced public health attention to those sources, including among self employed individuals, not currently subject to OSHA regulation.

Because lead interferes with biochemical processes occurring in cells throughout the body, adverse effects occur in multiple organ systems. The non-uniformity of symptoms that appear in exposed individuals, as well as a growing body of epidemiologic studies, suggest that wide variation exists in individual susceptibility to lead poisoning. Early overt symptoms in adults are often subtle and nonspecific, involving the nervous, gastrointestinal, or musculoskeletal systems. High levels of exposure can result in delirium, seizures, stupor, coma, or lead colic. Other overt signs and symptoms include hypertension, peripheral neuropathy, ataxia, tremor, gout, nephropathy, and anemia. In general, symptoms increase with increasing BLLs.

In addition to exposure that occurs from external sources, carefully performed lead isotope studies demonstrated that pregnancy and lactation are both associated with large increases in the release of lead from the maternal skeleton (Gulson et al. 2003). High levels of lead in women's bones at the time of childbirth corresponded to lower birth weight (Gonzalez-Cossio et al. 1997), lower weight gain from birth to one month of age (Sanin et al. 2001), and reduced head circumference and birth length (Hernandez-Avila et al. 2002).

In males, abnormal sperm morphology and decreased sperm count have been observed at BLLs of approximately 40 µg/dL (1.93 µmol/L) or less (Telisman et al. 2000). In the absence of effects on sperm count or concentration, the impact of paternal lead exposure on reproductive outcome is uncertain.

Recent research has examined several genetic polymorphisms that may influence lead uptake, distribution, and target organ toxicity. However, at this point in time, research findings are insufficient to conclusively identify subpopulations that may have increased susceptibility to lead toxicity based on specific genotypes. Other factors that might modify the risk of lead toxicity include pre-existing disease affecting relevant target organs (such as diabetic nephropathy or borderline hypertension), nutritional deficiencies (particularly of dietary cations such as iron and calcium), ethnicity, and aging.

CLINICAL ASSESSMENT OF LEAD EXPOSURE

Taking a detailed medical and occupational/environmental history is a fundamental step in the assessment of a person with lead exposure. It is important to ask about exposure to lead in current and previous jobs (Table 1), protections used, biological and air monitoring data, hygiene practices, knowledge and training, hobbies, traditional medications, moonshine use and other non-occupational sources (Table 2). A medical and reproductive history is essential in identifying individuals at increased risk of adverse health effects from lead exposure. Table 3 summarizes symptoms and target organ toxicity of lead at progressive BLLs. Physical exam findings in lead poisoning are frequently lacking. Gingival lead lines and wrist or foot drop are rarely seen.

Blood Lead Level and Zinc Protoporphyrin

The BLL is the most convenient and readily interpretable of the available lead biomarkers. It is mainly an estimate of recent external exposure to lead, but it is also in equilibrium with bone lead stores. The BLL alone is not a reliable indicator of prior or cumulative dose or total body burden; nor can a single BLL be used to confirm or deny the presence of chronic health effects thought due to lead exposure. The “normal” or “reference range” BLL is less than 5 µg/dL (0.24 µmol/L) for more than 90% (CDC 2005) of the adult population. When interpreting the BLL, key questions are whether the exposure has been 1) of short-term or long-term duration; 2) recent or in the remote past; and 3) of high or low intensity.

Erythrocyte protoporphyrin IX (EP), which can be measured as free EP (FEP) or zinc protoporphyrin (ZPP), is a measurement of biological effect and is an indirect reflection of lead exposure. Lead affects the heme synthesis pathway. Increases in EP or ZPP are not detectable until BLLs reach 20 to 25 µg/dL, (0.97-1.21 µmol/L) followed by an exponential rise relative to increasing BLLs. An increase in EP or ZPP usually lags behind an increase in BLL by two to six weeks.

Periodic testing of BLL and ZPP, called biological monitoring, is required by the OSHA lead standards for workers exposed to significant levels of airborne lead.

Other Laboratory Tests

Depending on the magnitude of lead exposure, a complete blood count, serum creatinine, blood urea nitrogen, and complete urinalysis may be indicated. Evaluation of reproductive status may be pertinent for some lead-exposed adults.

It is important to check BLLs of family members, particularly children, of lead-exposed individuals. Lead workers may unwittingly expose their families to lead dust brought home on clothes, shoes and in cars.

Except for rare circumstances, there is little or no value in measuring lead in urine or hair. Because of the pharmacokinetics of lead clearance, urine lead changes more rapidly and may vary independently of BLL. Urine lead is less validated than BLL as a biomarker of external exposure, or as a predictor of health effects. Lead in hair may be a reflection of external contamination rather than internal lead dose; laboratory analysis is not standardized.

EXPOSURE INVESTIGATION

The occupational and environmental exposure history is the first step in identifying the source of the lead exposure. Both because the cornerstone of intervention is source removal or reduction and because others may be at risk from exposure, the first step is to identify the source. A list of US Environmental Protection Agency accredited laboratories is available at <http://www.epa.gov/lead/nllaplist.pdf>. Assistance, especially for non-occupational problems such as herbal remedies, candy, moonshine etc. is available from the local and/or state health departments at http://www.apha.org/public_health/state.htm.

The clinician, with the patient's permission, should also contact the employer for further exposure information, such as air level monitoring, biologic monitoring and Material Safety Data Sheets (MSDSs). Work related exposure measurements should be readily available to the clinician. The federal OSHA standards are available at <http://www.osha.gov/SLTC/lead/standards.html>. Small businesses can obtain information at <http://www.osha.gov/dcsp/smallbusiness/index.html>

HEALTH-BASED MEDICAL MANAGEMENT

The single most important aspect of treating lead poisoning is removal from exposure, yet there may be important socioeconomic constraints for a given individual that limit this approach. For this reason, the panel and the AOEC petition OSHA to update the requirements of the current lead standards and urge clinicians to engage public health and industrial hygiene professionals whenever lead exposure is suspected.

Documented health risks and medical management recommendations are summarized in Table 4. The table presents recommendations for a broad range of BLLs. Although the BLL range is categorized in discrete steps, the outcomes will not neatly conform to these arbitrary divisions, and expectation of health effects in the BLL categories will also be influenced by cumulation of dose. For example, clinical peripheral neuropathy can be present at the high end of the BLL 40 to 79 $\mu\text{g}/\text{dL}$ (1.93-3.81 $\mu\text{mol}/\text{L}$) range, while it would not be expected to occur from lead exposure at the low end of the same range. The table is intended to assist clinicians in discussing the short-term and long-term health risks of lead exposure with their patients.

There are other instances where removal from lead exposure is warranted that are consistent with the OSHA lead standards. In addition to specific "trigger" BLLs for medical removal protection (MRP), under the OSHA lead standards (e.g. BLL 50 $\mu\text{g}/\text{dL}$ (2.41 $\mu\text{mol}/\text{L}$) or greater) the physician can remove an individual from lead work due to a medical condition which places the employee "at increased risk of material impairment to health from exposure to lead", chronic renal dysfunction (serum creatinine > 1.5 mg/dL (133 $\mu\text{mol}/\text{L}$) for men, > 1.3 mg/dL (115 $\mu\text{mol}/\text{L}$) for women, or proteinuria), hypertension, neurological disorders, cognitive dysfunction, and pregnancy.

Central nervous system effects may have a delayed onset and may sometimes persist well after the BLL has dropped below the BLLs at which the OSHA lead standards permit return to work. These persistent effects could negatively impact work performance and safety in certain jobs. Anecdotal evidence, and analogy to other neurotoxic injury, suggests that individuals who develop overt neurological signs and symptoms from lead exposure above that permissible under current OSHA regulations may benefit from rehabilitative measures (e.g., physical therapy, cognitive rehabilitation) that have been used effectively in patients with other brain injuries, such as traumatic brain injury or stroke. Participation in a rehabilitation

program may enhance the prospect for recovery, and may demonstrate the worker's capacity to safely return to work. ¹

Medical Surveillance

Medical surveillance is an essential part of an employer's lead safety program and includes biological monitoring with periodic BLL testing, medical evaluation, and treatment if needed, and intervention to prevent or control identified exposure. The BLL is the best available measure of total exposure from both inhalation and ingestion. Biological monitoring provides feedback to the employer and worker about the efficacy of workplace controls, helps avoid surprises, and saves costs such as medical removal.

Currently, under the OSHA standards, a worker must be included in a lead medical surveillance program if his/her airborne lead exposure is $30 \mu\text{g}/\text{m}^3$ (eight-hour time-weighted average) or higher for more than 30 days per year. The panel believes that the trigger for medical surveillance should not rely solely on air monitoring results; instead, workers should be included in a medical surveillance program whenever they are handling or disturbing materials with a significant lead content in a manner that could reasonably be expected to cause potentially harmful exposure through inhalation or ingestion.

A medical surveillance program with increased frequency of BLL testing and early intervention for all lead-exposed workers is recommended to reduce health risks. The panel does not recommend routine ZPP testing as an early biomarker of lead toxicity; however, ZPP measurement is required by OSHA for certain levels of lead exposure. New employees and those newly assigned to lead work should have a preplacement lead medical examination and BLL test, followed by periodic BLL testing, blood pressure measurement, and health status review. Monthly BLL testing is recommended for the first three months of employment for an initial assessment of the adequacy of exposure control measures. Subsequently, testing frequency can be reduced to every six months as long as BLLs remain below $10 \mu\text{g}/\text{dL}$ ($0.48 \mu\text{mol}/\text{L}$). Any increase in BLL of $5 \mu\text{g}/\text{dL}$ ($0.24 \mu\text{mol}/\text{L}$) or greater should be addressed by re-examining control measures in place to see where improvements should be made and by increasing BLL monitoring if needed. If the task assignment changes to work with significantly higher exposures, the initial BLL testing schedule of monthly tests for the first three months at this task should be repeated.

The above schedule for BLL testing may be inadequate for certain situations where the exposures are very high and/or highly variable. In these situations, the BLL testing schedule should be tailored to address the special risks of different types of work and exposures. For example, a construction worker may have very high, intermittent exposures in contrast to someone working in a battery plant or other general industry setting with significant exposures but less day-to-day variability. Employees assigned to tasks where exposures are extremely high (e.g., abrasive blasting) should be tested more frequently than as recommended above,

i.e., at least monthly. In general, it is a good idea to do BLL testing at peak exposures to assess controls and, specifically for the construction trades, to test pre-, mid-, and post-job.

Because of the significant reduction of lead in the general environment, new workers enter lead jobs with very low BLLs while others who have worked with lead often have much higher BLLs and body burdens. With increased biological monitoring frequency to ensure that low BLLs are maintained, it is possible that some workers with lead-related health risks may be able to work safely in a lead-exposed environment. All lead-exposed workers should receive education about the health effects of lead and prevention information from the clinician and the employer, and they should be provided necessary protections including protective clothing, clean eating areas, and hygiene measures such as wash-up facilities and/or showers to prevent both ingestion of lead and take-home exposures.

Chelation Therapy

Primary management for adult lead poisoning is identification of the lead source and cessation of exposure. In adults, chelation therapy generally should be reserved for individuals with high BLLs and/or significant symptoms or signs of toxicity. There is no evidence-based guidance in this regard because of lack of appropriate studies.

Based upon the clinical experience and judgment of panel members, the following general recommendations concerning chelation are offered: chelation therapy is *recommended* for adults with BLLs 100 µg/dL (4.83 µmol/L) or greater, can be *strongly considered* for BLLs 80 to 99 µg/dL (3.86-4.78 µmol/L), and *possibly considered* for BLLs between 50 and 79 µg/dL (2.41-3.81 µmol/L) in the presence of lead-related symptoms. BLLs greater than 100 µg/dL (4.83 µmol/L) almost always warrant chelation as they are usually associated with significant symptoms and may be associated with an incipient risk of encephalopathy or seizures. These are general recommendations and clinicians may vary appropriately from these recommendations depending upon circumstances. Adults with a very high BLL (e.g., 90 µg/dL (4.34 µmol/L)) may remain asymptomatic. Oral chelation has largely supplanted parenteral agents. Chelation therapy relies on enhancing renal excretion, and remobilization of lead from other body stores may occur. Guidance on administration of chelating agents is available in several publications (e.g. Kosnett 2004). Clinicians unfamiliar with chelation protocols are encouraged to contact AOEC clinics (<http://www.aoec.org/directory.htm> or 1-888-347-2632) or with other physicians experienced in treating adults with lead poisoning for additional advice prior to instituting treatment.

On a population basis it is important to reduce fetal exposure to lead, and maternal lead levels less than 5 µg/dL are optimal. However, laboratory measures are not absolutely precise, and clinical judgment is needed in every patient encounter. Chelation should be used during pregnancy ONLY to protect the life and health of the mother and ONLY if the potential benefit to the mother justifies the potential risk to the fetus. This decision will need to be made on a case by case basis by the attending physician. Because of the increase in lead mobilized from maternal bone during pregnancy, clinicians should be aware that maternal blood lead levels may exhibit an upward trend in the second and third trimesters even in the absence of further

exposure. Women with a history of long-term lead exposure or prior elevated BLL's should be monitored regularly during pregnancy for BLL elevation. If the occupational history or clinical evaluation suggests elevated bone lead stores, clinicians may wish to counsel patients on delaying conception until the risk of mobilization of lead from bone depots has been reduced.

Prophylactic chelation therapy of lead-exposed workers, to prevent elevated BLLs or to routinely lower BLLs to pre-designated concentrations believed to be “safe,” is prohibited by OSHA. Non-traditional uses of chelation therapy are not advised. There is no established basis to initiate chelation based on results of hair analysis or, in most cases, urine lead levels nor for chelation of asymptomatic individuals with low blood lead concentrations. Chelation should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus. Breast feeding during chelation therapy is not recommended. The effect of chelating agents on the fetus and newborn is unknown.

Pregnancy and Breast Feeding Concerns

Prevention of fetal and postnatal lead exposure of breastfed infants requires identification and control of sources of environmental and occupational lead exposures (both endogenous and exogenous) for pregnant and lactating women. The CDC has established 10 µg/dL (0.48 µmol/L) as a BLL of concern in children (CDC 2002).

Because fetal blood contains approximately 80% of the blood lead concentration of the mother, and because of the risk of spontaneous abortion, the panel’s recommendation is that the mother’s BLL should be kept below 5 µg/dL (0.24 µmol/L) from the time of conception through pregnancy. For women with a history of lead exposure, calcium supplementation during pregnancy may be especially important and may thus minimize release of lead from bone stores and subsequent fetal lead exposure.

In a recent prospective study, umbilical cord BLL and maternal bone lead measured shortly postpartum were independent risk factors for impaired mental development of the infants assessed at 24 months of age, even after controlling for contemporaneous BLL (Gomaa et al. 2002). Long-term prospective studies suggest that the adverse neurodevelopmental effects of prenatal lead exposure may not persist into adolescence if early postnatal exposure falls to background levels (Bellinger et al. 1990, 1992; Tong et al. 1996). However, maternal BLL measured during pregnancy has been associated with alterations in brainstem auditory response at in the offspring at age five (Rothenberg et al. 2000), and in retinal response at age 10 (Rothenberg et al. 2002b).

Lead does not concentrate in breast milk because it does not bind to nor dissolve in fat; thus, levels of lead are generally higher in a mother’s blood than in her milk. Lead in human breast milk appears to be well-absorbed by breast fed infants. Nevertheless, breast feeding should be encouraged in most situations since the benefits generally outweigh the negatives. Decisions relating to lactating women with evidence of very high lead exposure should be made on an individual basis.

If elevated maternal blood lead is suspected or demonstrated, the source(s) of lead exposure in the mother's diet, home, and work environment should be identified and mitigated. Also, the clinician should monitor infant BLLs during the early weeks of breast feeding. Only upon detection and elimination of all other suspected lead sources without corresponding reduction of infant BLL should cessation of breast feeding be advised.

Retained Bullet

Gunshot injuries to the head, face, and neck may be associated with swallowed bullets, fragments, or pellets, which result in a rapid increase in blood lead in the first days following injury. After detection of bullet fragments in the gut with X-rays, efforts to promote gastrointestinal decontamination may result in a gradual reduction of blood lead over the following weeks. Retained bullets or fragments, particularly those in joint spaces, are risk factors for elevated BLL after injury. Decisions to remove bullet fragments imbedded in tissue should be made in consultation between the treating physician and the surgeon. Individuals with retained bullets should receive baseline and periodic blood lead testing to monitor their lead status. Follow-up blood lead levels may not be needed if the bullets are in muscle tissue and physicians are sure the lead fragments have not migrated from muscle into tissues more likely to allow lead uptake.

CONCLUSIONS

AOEC offers these Guidelines as a resource for health care providers, public health professionals, employers, and others to utilize in providing medical management of lead-exposed adults. In this document, the panel has summarized the current scientific evidence concerning the non-carcinogenic adverse health effects in adults from exposure to inorganic lead.

The toxic effects of lead can occur without overt symptoms. A substantial body of recent research demonstrates a high probability that lead exposure at levels previously thought to be of little concern can result in an increased risk of adverse chronic health effects if the exposure is maintained for many years, thereby resulting in a progressively larger cumulative dose. Such effects may include elevations in blood pressure and increased risk of hypertension, kidney disease, cognitive dysfunction and/or accelerated declines in cognitive function, and reproductive risks.

Prevention of lead exposure should remain the primary goal of health care providers, public health professionals, and employers. Biological monitoring, mainly by periodic measurement of blood lead levels (BLLs) for adults engaged in activity with potential exposure to lead, should be conducted routinely to assess the efficacy of primary prevention and to guide the clinician in determining whether exposure has become excessive. Clinicians are encouraged to advise patients of the risks associated with any elevation of lead level and to advocate strongly for environmental controls that would maintain BLLs below 10 µg/dL (0.48 µmol/L) wherever feasible.

TABLE 1

Jobs and Industries with Potential Lead Exposure

<i>General Industry</i>	
Lead production or smelting Brass, bronze, copper, or lead foundries Ammunition/explosives production Scrap metal handling Firing ranges Machining or grinding lead alloys Manufacture of radiation shielding Repair/replacement of refractory material in furnaces Ship building/repairing/breaking Mining	Battery manufacturing or recycling Automotive radiator repair Lead soldering Ceramic manufacturing Cable/wire stripping, splicing or production Rubber manufacturing Plastics manufacturing Leaded glass manufacturing Paint/pigment manufacturing
<i>Construction</i>	
Renovation, repair or demolition of structures with lead paint Welding or torch-cutting painted metal Sandblasting, sanding, scraping, burning, or disturbing lead paint	Use or disturbance of lead solder, sheeting, flashing, or old electrical conduit Plumbing, particularly in older buildings

TABLE 2

Non-occupational and Environmental Sources of Lead Exposure

Remodeling or painting pre-1978 housing	Lead solder in stained-glass artwork
Peeling paint	Lead-soldered cans
Ethnic medicines or folk remedies (e.g., azarcon, greta, pay-loo-ah, kandu, some Ayurvedics)	Lead-contaminated candies
Pica (ingestion of lead-containing nonfood items, e.g., soil or ceramics, plaster, or paint chips)	Backyard scrap metal recycling
Retained lead bullet or fragments	Moonshine (liquor from a homemade still)
Melting lead for fishing weights, bullets, or toys	Antique pewter plates, mugs, utensils, toys
Imported vinyl miniblinds	Imported brass or bronze kettles, cookware
Recreational target shooting	Lead-glazed tableware or cooking vessels
Lead-contaminated drinking water supply	Leaded crystal tableware
Using lead glazes for ceramics	Mine tailings
Painting/stripping cars, boats, bicycles	Beauty products such as kohl eye make-up, certain hair dyes

TABLE 3
Health Effects to Lead Exposed Adults by Blood Lead Level

Blood Lead Level (µg/dL) (µmol/L)				
5-9(0.24-0.43)	10-19(0.48-0.92)	20-39(0.97-1.88)	40-79(1.93-3.81)	≥ 80(≥ 3.86)
<ul style="list-style-type: none"> ‣ Possible adverse population effects suggested by epidemiological studies 	<ul style="list-style-type: none"> ‣ Possible spontaneous abortion ‣ Reduced newborn birth weight ‣ Possible blood pressure changes ‣ Possible renal dysfunction 	<ul style="list-style-type: none"> ‣ Spontaneous abortion ‣ Reduced newborn birth weight ‣ Possible blood pressure changes ‣ Possible renal dysfunction ‣ Possible non-specific symptoms <ul style="list-style-type: none"> -Headache -Fatigue -Sleep disturbance -Anorexia -Constipation -Diarrhea -Arthralgia -Myalgia -Decreased Libido -Mood Swings, personality changes ‣ Possible CNS effects <ul style="list-style-type: none"> -Memory and attention deficits 	<ul style="list-style-type: none"> ‣ Spontaneous abortion ‣ Reduced newborn birth weight ‣ Non-specific symptoms ‣ CNS effects ‣ Sperm effects <ul style="list-style-type: none"> -lowered counts -abnormal sperm ‣ Subclinical peripheral neuropathy ‣ Possible hypertension ‣ Possible anemia ‣ Possible renal damage ‣ Possible gout 	<ul style="list-style-type: none"> ‣ Spontaneous abortion ‣ Reduced newborn birth weight ‣ Non-specific symptoms ‣ CNS effects ‣ Sperm effects ‣ Peripheral Neuropathy ‣ Hypertension ‣ Anemia ‣ Abdominal Colic ‣ Nephropathy ‣ Gout

TABLE 4
Health Based Management Guidelines

Blood Lead Level (µg/dL) (µmol/L)			
5-9(0.24-0.43)	10-29(0.48-1.40)	30-79**(1.45-3.81)**	≥ 80(≥ 3.86)
<ul style="list-style-type: none"> ▸ Lead education <ul style="list-style-type: none"> -Occupational -Environmental -Reproductive ▸ Follow-up blood lead levels (BLLs) 	<ul style="list-style-type: none"> ▸ Consider clinical assessment <ul style="list-style-type: none"> -History: <ul style="list-style-type: none"> occupational environmental medical -Exam, labs -Identify risk factors -Family BLLs ▸ Exposure investigation <ul style="list-style-type: none"> -MSDSs -Air testing -Workplace communication ▸ Consider consultations <ul style="list-style-type: none"> -Occupational Medicine -Industrial Hygienist -Public Health department ▸ Lead hazard reduction ▸ Consider removal from lead exposure if warranted ▸ Lead education ▸ Follow-up BLLs (See Medical Surveillance recommendations) 	<ul style="list-style-type: none"> ▸ Lead education ▸ Clinical assessment <ul style="list-style-type: none"> -History -Exam, labs (BUN, Cr, CBC) -Identify risk factors -Family BLLs ▸ Exposure Assessment ▸ Consultations as appropriate ▸ Lead Hazard Reduction ▸ Removal from lead exposure** ▸ Possible chelation for BLL>50 with signs or symptoms of toxicity ▸ Medical Surveillance <ul style="list-style-type: none"> -Follow-up BLLs -Follow-up clinical assessments <p><i>**Note this is the recommendation by AOEC. Consult the OSHA Standard for the levels currently defined in regulation which provides workers' protections.</i></p>	<ul style="list-style-type: none"> ▸ Immediate removal from lead exposure ▸ Refer for immediate/urgent medical evaluation and consideration of chelation therapy ▸ Clinical assessment ▸ Lead education ▸ Exposure investigation ▸ Consultations ▸ Lead hazard reduction ▸ Medical surveillance

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