California Department of Public Health
OCCUPATIONAL LEAD POISONING PREVENTION PROGRAM

Medical Guidelines *for the* Lead-Exposed Worker

IN BRIEF...

- **Thousands of workers in California are still exposed to lead at levels that can have adverse health effects.**
- **Recent research findings increase concern about the toxicity of low-dose lead to adults.**
- **Learn what you must do to protect the health of lead-exposed workers.**

INSIDE...

- **Comprehensive health-based recommendations based on the latest scientific information for diagnosing, monitoring, and treating workers with acute and/or chronic lead poisoning.**
- **Summarized in easy-to-reference tables.**

California Department of PublicHealth **OLPPP** Occupational Lead Poisoning Prevention Program

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INTRODUCTION

Lead exposure may occur in more than 100 industries in the United States (Table 1). Although the toxic effects of lead have been known for centuries, harmful lead exposures are still widespread. Adults are primarily exposed in the workplace. Lead affects multiple body systems and can cause permanent damage. Lead exposure, if undetected, often results in misdiagnosis and costly care. Many workers with lead toxicity do not receive medical attention and, for those who do, follow-up may not be adequate to prevent future lead poisoning.[1] Studies have shown that only a small percentage of employers in some lead industries provide routine blood lead testing for lead-exposed employees in spite of regulatory requirements.[2, 3]

Medical care of lead-exposed workers in California has been guided by the Cal/OSHA lead standards released in 1979 for general industry and in 1993 for the construction industry. However, in the past 30 years, information published in peer-reviewed medical and scientific journals has demonstrated harmful effects of chronic and low-level exposures to lead in adults. These Medical Guidelines for the Lead-Exposed Worker, prepared by the California Department of Public Health's Occupational Lead Poisoning Prevention Program (OLPPP), review the more recent scientific information of importance to clinicians caring for lead-exposed adults and make health-based recommendations on how to provide state-of-the-art care for patients while assuring compliance with the Cal/OSHA lead standards and workers' compensation requirements. The Guidelines also summarize the Cal/OSHA lead standards and present information to assist in providing appropriate service to the employers of lead-exposed workers.

Table 1
Work Associated with Lead Exposure

Industry Type	Work Activities
General Industry	➔ Lead production or smelting ➔ Battery manufacturing or recycling ➔ Brass, bronze, or lead foundries ➔ Metal radiator repair ➔ Scrap metal handling ➔ Recycling of lead-sheathed cables ➔ Lead soldering ➔ Firing ranges ➔ Ceramics manufacturing ➔ Machining or grinding metal alloys containing lead ➔ Plastics manufacturing
Construction Industry	➔ Sanding, scraping, burning, or disturbing lead paint ➔ Demolition of old structures ➔ Welding or torch cutting lead-painted metal ➔ Abrasive blasting ➔ Construction or repair of bridges, water towers, tanks, roofing ➔ Lead abatement ➔ Painting—residential or commercial ➔ Renovation or remodeling structures built before 1978 ➔ Welding on metal structures

TOXICOLOGY

Background

Lead is not an essential element and serves no useful purpose in the body. Acute, high-dose lead poisoning with findings such as headache, malaise, and crampy abdominal pain is now relatively uncommon. However, low exposures that in the past were without recognized harm are now considered hazardous as new information continues to emerge about the toxicity of low dose and cumulative lead exposures. Efforts to reduce lead in the environment have resulted in a decline in the geometric mean blood lead level (BLL) for adults in the United States from more than 12 micrograms of lead per deciliter of blood (mcg or µg/dL) in 1980 to less than 2 µg/dL in 2002.[4] However, even though the average BLL in the general population has markedly declined, many workers with high-risk jobs are still overexposed to lead. Exposures in the U.S. are primarily to the inorganic form of lead.

Routes of exposure for inorganic lead are inhalation and ingestion. Lead fume and soluble lead dust are nearly completely (~80%) absorbed by inhalation. In general, adults absorb about 10-15% of an ingested dose through the gastrointestinal tract, in contrast to 50% absorption for children. Once absorbed, lead is found in all tissues but eventually 90% or more of the body burden is accumulated (or redistributed) into bone. Lead does not remain in the bone permanently; rather, it is slowly released back into the blood with a half-life of years to decades. Lead is excreted primarily through the urine with smaller amounts in feces, sweat, hair, and nails.

Health Effects

Lead adversely affects multiple organ systems and can cause permanent damage. In addition to the symptoms associated with acute, high-dose exposures, there is increasing concern with regard to the sometimes subclinical health effects linked to chronic, lower-dose exposures including hypertension, effects on renal function, cognitive dysfunction, and adverse female reproductive outcomes. Current concern over the adverse health risks associated with lead exposure in adults starts at a BLL of 5 µg/dL for adverse female reproductive outcomes and at 10 µg/dL for the other health effects listed above.[5]

In general, the number and severity of overt symptoms worsen with increasing BLL (Table 2). Early symptoms are often subtle and nonspecific, involving the nervous system (fatigue, irritability, sleep disturbance, headache, difficulty concentrating, decreased libido), the gastrointestinal system (abdominal cramps, anorexia, nausea, constipation, diarrhea), or the musculoskeletal system (arthralgia, myalgia). A high level of intoxication can result in delirium, seizures, and coma associated with lead encephalopathy, a life-threatening condition. Symptoms may lag physiological changes. Some individuals may be unaware of any symptoms even though they are experiencing lead toxicity.

Research shows multiple health effects at BLLs once thought to be without recognized harm (Table 3).[5] A recent review concluded that evidence is now sufficient to infer a causal relationship of lead exposure with hypertension.[6] Since hypertension is a significant risk factor for heart disease, stroke, and renal insufficiency, lead exposure may exert an important influence on cardiovascular, cerebrovascular, and renovascular mortality.

Early kidney damage is difficult to detect. However, a 10 µg/dL increase in BLL has been associated with a 10.4 mL/minute decrease in creatinine clearance.[7] In a population of older men with a mean BLL of 8.6 µg/dL (range 0.2-54.1), a 10-fold increase in BLL predicted an increase of 0.08 mg/dL in serum creatinine concentration, roughly equivalent to 20 years of aging.[8]

Another recent review concluded that there is an association between BLLs and decrements in cognitive function in adults.[9] A study of currently exposed lead workers (mean age 40.4 years) showed that a 5 µg/dL increase in BLL had the same negative influence on cognitive function as an increase of 1.05 years of age.[10] Subclinical slowing of nerve conduction velocity has been seen at BLLs as low as 30 µg/dL.[11] Because of the blood-brain barrier, lead and other heavy metals are slow to enter and leave the brain tissue. Central nervous system effects may sometimes persist well after the BLL has dropped. These effects may negatively impact job performance and safety.

Table 2
Symptoms Associated with Lead Toxicity

Toxicity	Findings
Mild	Mild fatigue or exhaustion; emotional irritability or lability; difficulty concentrating; sleep disturbances
Moderate	Headache; general fatigue or somnolence; myalgia, arthralgia, tremor; nausea; decreased appetite; abdominal cramps, constipation or diarrhea; decreased libido
Severe	Colic (intermittent, severe abdominal cramps); peripheral neuropathy; encephalopathy

While a decrease in hemoglobin was previously associated with BLLs above 50 µg/dL, a study using K-shell X-ray fluorescence measurement of lead in bone has found that bone lead levels were significantly correlated with a decrease in hemoglobin and hematocrit even though BLLs were low (mean 8.3 µg/dL); this may reflect a subclinical effect of bone lead stores on hematopoiesis.[12]

Abnormal sperm morphology and decreased sperm count have been observed at approximately 40 µg/dL.[13, 14]

In a cohort of 668 pregnant women seeking prenatal care in Mexico City, it was found that women whose BLLs were 5-9, 10-14, and > 15 µg/dL had elevated odds ratios for spontaneous abortion of 2.3, 5.4, and 12.2, respectively, as compared with the reference category of women with < 5 µg/dL of blood lead.[15] Lead readily crosses the placenta and is present in breast milk.[16] Lead exposure during pregnancy affects children's physical development measured during the neonatal period and in early childhood.[17, 18, 19] Elevated maternal BLLs have also been associated with poorer infant mental development and adverse impacts on postnatal neurobehavioral development.[20, 21, 22]

Household members of workers with lead exposure are at increased risk for lead poisoning if lead is carried home on the worker's body, clothes, shoes, or in the personal vehicle (called "take-home" exposure). Children under six years old and the fetus are especially sensitive to neurological damage. Available evidence suggests there is no BLL without risk of health effects in these populations.[23]

Testing

The single best diagnostic test for lead exposure is the blood lead level. It reflects the amount of lead currently found in the blood and soft tissues (and hence key target organs). The BLL alone is not a reliable indicator of prior or current exposure, or total body burden. BLLs reflect the contributions of recent external exposure to lead as well as the release of internal bone lead stores into the blood. As such, BLLs represent a mixture of both external exposure and internal lead stores.[24] When interpreting a person's blood lead level, three key questions to keep in mind are whether the exposure history has been:

- acute or chronic?
- recent or remote?
- high or low?

Periodic testing of BLL is called biological monitoring. This provides valuable information to assess lead exposure for individuals as well as groups of workers. Note that a detailed exposure history is an essential part of evaluating and interpreting biological monitoring information.

While the Cal/OSHA lead standards require zinc protoporphyrin (ZPP) testing, this is an indirect and insensitive biomarker of lead absorption. An elevated ZPP may indicate that lead is affecting the heme synthesis pathway. This effect can begin at a BLL as low as 20 µg/dL in some adults but is not greater than 90% sensitive until the BLL exceeds 50 µg/dL. An increase in ZPP usually lags an increase in BLL by two to six weeks. Therefore, a normal EP or ZPP in the presence of an elevated BLL suggests recent exposure. OLPPP recommends that routine measurement of ZPP be undertaken only when necessary to comply with the Cal/OSHA lead standards. Other medical conditions can cause an elevated ZPP, the most common being iron deficiency anemia, porphyria, and inflammatory conditions.[25, 26] The upper limit of normal for ZPP varies some between labs but is usually between 35 and 40 µg/dL.

MEDICAL TREATMENT

The primary therapy for lead poisoning is cessation of exposure.

Recent research findings, as noted above in the Toxicology section, have prompted revised health-based management recommendations for lead-exposed adults. These recommendations and the adverse health risks associated with short-term and long-term exposures at different BLLs are summarized in Table 3.[5]

Chelation Therapy

In adults, the use of chelation therapy is generally reserved for those with symptoms or signs of severe toxicity and/or very high BLLs. While uncommon, adults may have a very high BLL (e.g., 80 - 99 µg/dL) and have no overt symptoms. These patients should be removed from exposure and followed carefully.

Patients with BLLs of 80-99 µg/dL, with or without symptoms, as well as some symptomatic individuals with BLLs of 50-79, can be considered for chelation. Levels above 100 µg/dL usually warrant chelation as they are often associated with significant symptoms and may be associated with an incipient risk of encephalopathy or seizures.[5]

Chelation therapy primarily reduces lead in the blood and soft tissues, such as liver and kidneys, and has a relatively smaller impact on the fraction of lead stored in bone. In patients with substantial bone lead stores who are chelated, re-equilibration of lead from bone back into blood and soft tissues may result in a rebound effect with a rise in the BLL after an initial drop. Symptoms associated with lead toxicity may recur.

Chelation guidelines are controversial and may change as new agents and information are introduced. Although chelation has been associated with improvement in symptoms and decreased mortality, controlled clinical trials demonstrating efficacy are lacking, and treatment recommendations have been largely empirical.[27]

Chelation therapy should not be initiated until after the individual has been removed from exposure and should not be continued if the individual returns to a lead exposure job. Chelation should be considered only on an individual case basis and in consultation with medical providers who are knowledgeable about treatment of adult lead poisoning.[28] A list of the University of California Occupational and Environmental Health Clinics is provided in the section titled "For Assistance."

Succimer is an oral chelating agent which increases the urinary excretion of lead. Although rare, neutropenia and elevated serum transaminases have been reported with succimer use and monitoring of complete blood counts and serum transaminases is recommended. Starting dosage is 10 mg/kg every eight hours for five days followed by 10 mg/kg every 12 hours for an additional two weeks (19 days total). Decisions on repeat courses are made based on weekly monitoring of BLLs.

Table 3
Health-based Management Recommendations for Lead-exposed Adults

Blood Lead Level (BLL) µg/dL	Short Term Risks Lead exposure < 1 year	Long Term Risks Lead exposure ≥ 1 year	Management
< 5	None documented	None documented	Indicated
5 – 9	Possible spontaneous abortion Possible postnatal developmental delay	Possible spontaneous abortion Possible postnatal developmental delay Possible hypertension and kidney dysfunction	Discuss health risks Reduce lead exposure for women who are or may become pregnant
10 – 19	Possible spontaneous abortion Possible postnatal developmental delay Reduced birth weight	Possible spontaneous abortion Reduced birth weight Possible postnatal developmental delay Hypertension and kidney dysfunction Possible subclinical neurocognitive deficits	As above for BLL 5-9 µg/dL, plus: Decrease lead exposure Increase biological monitoring Consider removal from lead exposure to avoid long-term risks if exposure control over an extended period does not decrease BLL below 10 µg/dL, or if medical condition present that increases risk with continued exposure*
20 – 29	Possible spontaneous abortion Possible postnatal developmental delay Reduced birth weight	Possible spontaneous abortion Possible postnatal developmental delay Reduced birth weight Hypertension and kidney dysfunction Possible subclinical neurocognitive deficits	Remove from lead exposure if repeat BLL measured in 4 weeks remains ≥ 20 µg/dL
30 – 39	Spontaneous abortion Possible postnatal developmental delay Reduced birth weight	Spontaneous abortion Reduced birth weight Possible postnatal developmental delay Hypertension and kidney dysfunction Possible neurocognitive deficits Possible non-specific symptoms**	Remove from lead exposure
40 – 79	Spontaneous abortion Reduced birth weight Possible postnatal developmental delay Non-specific symptoms** Neurocognitive deficits Sperm abnormalities	Spontaneous abortion Reduced birth weight Possible postnatal developmental delay Non-specific symptoms** Hypertension Kidney dysfunction/nephropathy Subclinical peripheral neuropathy Neurocognitive deficits Sperm abnormalities Anemia Colic Possible gout	Remove from lead exposure Refer for prompt medical evaluation Consider chelation therapy for BLL over 50 µg/dL with significant symptoms or signs of lead toxicity
≥ 80	Spontaneous abortion Reduced birth weight Possible postnatal developmental delay Non-specific symptoms** Neurocognitive deficits Encephalopathy Sperm abnormalities Anemia Colic	Spontaneous abortion Reduced birth weight Possible postnatal developmental delay Non-specific symptoms** Hypertension Nephropathy Peripheral neuropathy Neurocognitive deficits Sperm abnormalities Anemia Colic Gout	Remove from lead exposure Refer for immediate/urgent medical evaluation Probable chelation therapy

* Medical conditions that may increase the risk of continued exposure include chronic renal dysfunction (serum creatinine > 1.5 mg/dL for men, > 1.3 mg/dL for women, or proteinuria), hypertension, neurological disorders, and cognitive dysfunction.
** Headache, fatigue, sleep disturbance, anorexia, constipation, arthralgia, myalgia, decreased libido, etc.
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CAL/OSHA LEAD STANDARDS

The Cal/OSHA general industry lead standard (Title 8 CCR §5198) was adopted in 1979 to reduce workplace exposures and to prevent frank lead poisoning through early identification of workers with elevated BLLs. In 1993, Cal/OSHA adopted a similar lead standard for the construction industry (Title 8 CCR §1532.1). While once considered protective, both standards are based on medical information that is now more than 30 years old. More recent scientific study shows that the standards are not adequately protective against the adverse health effects of lead absorption from both acute and cumulative lead exposures. A brief review of key requirements of the lead standards is presented below.

The lead standards delineate the employer's responsibilities to lead-exposed employees (Table 4). Note that employers are required to pay for all medical monitoring and to continue to pay the salary and benefits of employees who are removed from work for medical reasons related to lead exposure. The lead standards require the employer to assure that all medical examinations and procedures are performed by or under the supervision of a licensed physician.

Table 4 Key Employer Responsibilities Under the OSHA Lead Standards

- Monitor the air for lead
- Keep air lead levels below 50 µg/m^3 (averaged over 8 hrs) using engineering or work practice controls
- Provide a respirator if employee requests, or if needed for exposure control
- Provide medical monitoring for employees
- Provide protective clothing, separate eating area, and washing facility for employees
- Train employees annually on:
  - sources of lead exposure
  - health hazards associated with lead
  - methods of reducing lead exposure
  - employee rights under the standards
- Maintain air monitoring and medical records related to lead exposure
- Pay employee's full salary during medical removal
- Make copy of standard available to employees and physicians
- Provide physicians with information on each employee's duties, exposure levels, and personal protective equipment; as well as prior BLLs and medical opinions
- Notify employee of BLL result within 5 days

Table 5 Key Physician Responsibilities Under the OSHA Lead Standards

- Be familiar with the lead standards
- Be informed about the health effects of lead and appropriate medical management
- Provide required biological monitoring and medical evaluations of employees
- Determine employee fitness for work with lead
- Make written recommendations to employer for initiating and discontinuing any restrictions including Medical Removal Protection (MRP)
- Provide employer with results relating only to employee's occupational exposure to lead
- Notify employee directly of any medical conditions requiring further evaluation
- Notify employee in writing prior to any chelation as to the reason for therapy
- Be informed about the work environment and any personal protective equipment used by employees, as possible
- Collaborate with employer to identify work areas or tasks associated with high exposure
- File Doctor's First Report of Injury or Illness for MRP cases within 5 days

Physicians caring for lead-exposed workers should know their responsibilities to the employer and employees under the lead standards (Table 5). The lead standards should be consulted prior to implementing a medical surveillance program. Copies of the standards and a model contract for a lead medical program for employers and physicians are available from OLPPP.

Under the Cal/OSHA lead standards, medical surveillance requirements are determined by a worker's exposure to lead in the air, by a worker's BLL and, in the construction trades, by work involving certain high-exposure "trigger tasks." OSHA defines the Action Level as an airborne lead concentration of 30 micrograms per cubic meter (µg/m^3). The Action Level triggers certain requirements of the standards including medical surveillance. The schedule for required minimum Medical Services per the Cal/OSHA lead standards is summarized in Tables 6 and 7. Additional information for clinicians is contained in Appendix C of both standards.

Cal/OSHA Lead Standards
Schedule for Required Medical Services

Table 6
General Industry (Title 8, California Code of Regulations, §5198)

Category of Exposure	Medical Evaluation	Laboratory Testing
Assigned to work with airborne lead exposure at or above 30 µg/m³* for more than 30 days per year.	Prior to assignment: General and lead-specific history and physical exam with special attention to hematological, neurological (central and peripheral), cardiopulmonary, gastrointestinal, musculoskeletal, renal and reproductive systems. Medical clearance to wear respirator, if used—applies to all categories.	Complete lab panel: BLL, ZPP, CBC with red cell indices and peripheral smear, serum creatinine, BUN, complete urinalysis. Sperm analysis or pregnancy test if employee requests. Any other test the physician deems necessary. Repeat BLL and ZPP every six months.
Blood lead level 40 µg/dL* or greater at last test, but Medical Removal Protection (MRP)** not required.	Annually (see above).	Complete lab panel if not done within last 12 months (see above). Repeat BLL and ZPP every two months until two consecutive BLLs are below 40 µg/dL.
Single BLL of 60 µg/dL or greater, or average BLL 50 µg/dL or greater based on the last three BLLs or all BLLs over the previous six months (whichever covers a longer time period)—Medical Removal Protection (MRP) required.**	As soon as MRP initiated (see above).	Complete lab panel (see above). Repeat BLL and ZPP at least monthly until two consecutive BLLs are at or below 40 µg/dL.
Reports signs/symptoms of lead toxicity, desires advice about effects of lead exposure (on reproductive system, child bearing, etc.), has increased risk of material impairment to health due to lead exposure, or has difficulty breathing with respirator use.	As soon as possible (see above).	As deemed appropriate by the physician based on individual case needs.

* µg/m³ = micrograms of lead per cubic meter of air; µg/dL = micrograms of lead per deciliter of whole blood.

** Medical Removal Protection is the required removal of an employee from work with lead exposure, with full salary and benefits, until there are two consecutive BLLs of 40 µg/dL or below and the physician authorizes return to the usual work.

Medical evaluations must also be performed as soon as possible if any of the following occur:

- an employee develops signs or symptoms commonly associated with lead toxicity,
- an employee plans to have children and wants medical advice concerning the effects of lead exposure, or
- an employee has difficulty breathing while using a respirator.

Additionally, medical evaluation as appropriate must be provided for an employee who is either removed from exposure to lead due to a risk of sustaining material impairment to health, or who requires special protections as determined by the physician.

To comply with the current Cal/OSHA lead standards, medical evaluations must include all of the elements listed in Tables 6 and 7. The physician may include any other medical tests that are deemed necessary based on sound medical practice. OLPPP recommends that all employees be notified of their test results. Notification forms in English, Spanish, and Chinese are available from OLPPP. As part of a complete respiratory protection program, Cal/OSHA requires medical clearance for any worker using a respirator (Title 8 CCR §5144, http://www.dir.ca.gov/title8/5144.html).

The Cal/OSHA lead standards allow a physician to remove an employee with a BLL below the specified MRP levels based on relevant medical findings in individual cases, such as pregnancy or symptoms commonly associated with lead toxicity. Whenever an employee is placed on MRP due to an elevated BLL, the frequency of biological monitoring must be increased to at least monthly. After two consecutive BLLs are 40 µg/dL or less, the physician can recommend to the employer that the employee return to

Table 7
Construction Industry (Title 8, California Code of Regulations, §1532.1)

Category of Exposure	Medical Evaluation	Laboratory Testing
New employees or those newly assigned to lead work who are performing a specific trigger task* or who are exposed to airborne lead at or above 30 µg/m^3** for 1 to 30 days per year and prior BLL, if known, is below 40 µg/dL.**	Medical clearance to wear respirator, if used—applies to all categories.	BLL and ZPP.
New employees or those newly assigned to work with airborne exposure at or above 30 µg/m^3 for more than 30 days per year and prior BLL, if known, is below 40 µg/dL.	Same as above.	BLL and ZPP. Repeat every two months for six months, then every six months thereafter.
Blood lead level 40 to 49 µg/dL.	Annually: General and lead-specific history and physical exam with special attention to hematological, neurological (central and peripheral), cardiopulmonary, gastrointestinal, musculoskeletal, renal and reproductive systems.	Complete lab panel: BLL, ZPP, CBC with red cell indices and peripheral smear, serum creatinine, BUN, complete urinalysis. Sperm analysis or pregnancy test if employee requests. Any other test the physician deems necessary. Repeat BLL and ZPP every two months until two consecutive BLLs are below 40 µg/dL.
Blood lead level 50 µg/dL or greater—Medical Removal Protection (MRP) required.***	As soon as MRP initiated (see above).	Complete lab panel (see above). Repeat BLL and ZPP at least monthly until two consecutive BLLs are at or below 40 µg/dL.
Reports signs/symptoms of lead toxicity, desires advice about effects of lead exposure (on reproductive system, child bearing, etc.), has increased risk of material impairment to health due to lead exposure, or has difficulty breathing with respirator use.	As soon as possible (see above).	As deemed appropriate by the physician based on individual case needs.

* Title 8, California Code of Regulations, Section 1532.1(d)(2).

** µg/m^3 = micrograms of lead per cubic meter of air; µg/dL = micrograms of lead per deciliter of whole blood.

*** Medical Removal Protection is the required removal of an employee from work with lead exposure, with full salary and benefits, until there are two consecutive BLLs of 40 µg/dL or below and the physician authorizes return to the usual work.

the previous work if the employer has taken steps to control lead exposure and the employee's symptoms or any other clinical manifestations of toxicity have resolved. OLPPP recommends these tests be at least one month apart to allow for mobilization and excretion of some of the lead burden.

The physician can allow an employee, if physically able, to work in an area free of lead exposure while on MRP. The standards permit a worker on MRP to work in any area where the 8-hour time-weighted average (TWA) air lead concentration is less than 30 µg/m^3. However, because significant lead exposure can occur even when air lead levels are not elevated (e.g., by hand-to-mouth ingestion), the supervising physician should carefully review the safety of any lead-related work for an employee on MRP. The most appropriate placement for a worker on MRP would be a job that avoids handling or disturbing materials with a significant lead content in a manner that could reasonably be expected to cause exposure through inhalation or ingestion. This will usually require transfer of the individual out of any environment or task that might be expected to raise the blood lead concentration of a person not using personal protective equipment above background levels (i.e., 2 µg/dL). The clinician should also assure that the individual does not have hobbies or other activities (e.g., home renovation) that may also cause lead exposure.

Note that the physician is only permitted to provide the employer with the results of the medical evaluation that relate to the employee's occupational exposure. The employer must forward a copy of the same written information to the employee. The physician should notify the employee directly of any other medical conditions that require further evaluation.

Placement of a worker on MRP is considered a reportable illness. The physician must file, with the employer's insurer or with the employer if self-insured, a Doctor's First Report of Occupational Injury or Illness within five days after initial examination for every employee with an occupational injury or illness (Title 8 CCR §14003). This form is available at http://www.dir.ca.gov/dlsr/dlsrform5021.pdf.

The standards require the employer to pay the employee's usual wage and benefits during the removal period, whether or not the employee is working. If workers' compensation disability benefits are used to pay a portion of the salary, the employer is responsible for paying the balance. Upon return to work, the employee is guaranteed their former job status with no loss of seniority.

Approved Labs

Blood lead analyses performed under the lead standards must be conducted by laboratories that meet OSHA requirements in blood lead proficiency testing. For a current list of approved laboratories or more information, contact the OSHA Salt Lake City Technical Center, Division of Quality Control, Salt Lake City, Utah (801/233-4927) or http://www.osha.gov/SLTC/bloodlead/index.html.

OLPPP RECOMMENDATIONS FOR CARE OF WORKERS

The medical practitioner has a primary responsibility to protect the health of the patient. When dealing with lead-exposed workers, additional responsibilities may include compliance with regulatory requirements and appropriately interacting with employers. At times, the mandated regulatory standards for action to be taken by the practitioner may be less stringent than those indicated by current medical knowledge. In such cases, the practitioner must evaluate the available options in order to meet the duty of patient care as well as regulatory compliance.

Both Cal/OSHA lead standards contain provisions which could form the basis for implementation of protective workplace action at the lower BLLs recommended by these OLPPP Medical Guidelines for the Lead-Exposed Worker. Both standards say an employee can be removed from lead work if the medical determination is that "the employee has a detected medical condition which places the employee at increased risk of material impairment to health from exposure to lead." Additionally, the Medical Surveillance Guidelines contained in Appendix C of both standards state the following: "Recommendations may be more stringent than the specific provisions of the standard.

Table 8
Health-Based Medical Surveillance Recommendations for Lead-Exposed Workers

Category of Exposure	Recommendations
All lead-exposed workers*	Baseline or preplacement medical history and physical examination, baseline blood lead level (BLL), serum creatinine.
Blood lead level (BLL)	
< 10 µg/dL	➔ BLL every month for first 3 months of placement, or upon change in task to higher exposure, then BLL every 6 months. ➔ If BLL increases > 5 µg/dL, evaluate exposure and protective measures. Increase monitoring if indicated. ➔ See Table 3 for pregnancy concerns.
10 – 19 µg/dL	➔ As above for BLL < 10 µg/dL, plus: ➔ BLL every 3 months. ➔ Evaluate exposure, engineering controls, and work practices. ➔ Consider removal (see Table 3). ➔ Revert to BLL every 6 months after 3 BLLs < 10 µg/dL.
> 20 µg/dL	➔ Remove from exposure if repeat BLL measured in 4 weeks remains ≥ 20 µg/dL, or if first BLL ≥ 30 µg/dL (see Table 3). ➔ Monthly BLL testing. ➔ Consider return to lead work after 2 BLLs < 15 µg/dL a month apart, then monitor as above.

* Lead-exposed means 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.

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The examining physician, therefore, is given broad flexibility to tailor specific protective procedures to the needs of individual employees." Given the evidence referenced herein, the practitioner may determine that BLLs at the lower levels discussed place the employee at such increased risk. Nonetheless, clinicians should inform patients that such recommendations may be contested by an employer or an insurer, and could potentially jeopardize their job benefits or work status. Prudent case management that considers the worker's perspective on their unique health risks and employment situation will usually be advisable.[5] OLPPP is available to consult on an individual basis with health care providers (and their patients or involved employers) regarding the implementation of these Guidelines.

The health care provider should consider initiating contact with the employer to explain why added protections (beyond current regulations) are needed for at-risk workers as well as to ensure that the employer understands language in the lead standard that supports the clinician's role in determining an appropriate course of action.

Tables 6 and 7 present the minimum Medical Services to be provided under the Cal/OSHA lead standards. Based on concern regarding adverse health effects of lead at lower BLLs, OLPPP recommends consideration of a revised schedule of medical surveillance activities that aims to better protect health by detecting and responding earlier to increases in BLL (Table 8).[5] Physicians may use their discretion to implement an increased frequency of blood lead testing based on Appendix C of both Cal/OSHA lead standards. Note that the baseline or preplacement medical history should include a detailed occupational and exposure history as well as a review of the job description, the tasks with direct lead exposure, and control measures such as use of personal protective equipment.

The medical practitioner can also play an additional important role by encouraging and assisting employers to improve workplace lead-related health and safety conditions. Employers can take steps to limit lead exposure to as low as possible, regardless of regulatory limits. Also, employers need to address the issue of take-home lead by providing and laundering work clothes, and providing showers and clean separate lockers for street clothes and footwear. Employers may be held liable for health damage to household members caused by an improperly protected worker who takes lead home. Site visits by a provider and collaboration with an industrial hygienist and/or the company personnel responsible for health and safety can be very useful in these situations. A health care provider responsible for overseeing the medical surveillance program can help to interpret the employees' BLL results, identifying priorities for workplace improvements in exposure control. Exposure control measures that can be implemented and/or improved to reduce employee BLLs include:

- substitution of lead-free materials and work processes;
- use of engineering controls such as local exhaust ventilation and safe work practices;
- good hygiene and decontamination practices to limit ingestion and the risk of take-home lead; and
- use of personal protective equipment (PPE) such as protective clothing and respirators.

With appropriate engineering controls, safe work practices, and personal protective equipment, workers without a previous history of substantial lead exposure should be able to work with lead in a manner that minimizes the potential for hazardous levels of exposure. However, in a worker with a long history of high exposure, redistribution of lead from a large internal skeletal burden may result in a prolonged elevation of blood lead concentration despite marked reductions in external lead dose.[5] For these individuals, BLLs may correlate with length of exposure and not current air lead levels.

SUMMARY

Lead poisoning is preventable. Medical surveillance is an important tool to identify excessive lead exposure and to direct and evaluate exposure reduction efforts. The overall goal is to reduce workers' BLLs to that of the general population. The key is exposure reduction through substitution, engineering controls, safe work practices, and appropriate use of PPE. It is worth noting that Medical Removal Protection levels were first established in 1977 when the assumed background BLL for the general population was 19 µg/dL (it is now about 2 µg/dL). Because current background BLLs are now far lower, careful attention to controlling workplace lead exposure should render it possible to maintain workers' BLLs below 10 µg/dL, especially in the case of workers without a history of high past exposure. Employers may need to obtain technical assistance in controlling exposures (see For Assistance, below). OLPPP, Cal/OSHA Consultation Service, and some workers' compensation insurers provide such assistance at no cost.

By working together, the employer and the clinician can use biomedical information to identify problems and implement improvements in the workplace. Given the scientific evidence on adverse health effects at chronic and lower BLLs, taking preventive actions to protect lead-exposed workers, even if not required under current occupational regulations, is both warranted and prudent.

FOR ASSISTANCE

Occupational Lead Poisoning Prevention Program (OLPPP)

Occupational Health Branch
California Department of Public Health
850 Marina Bay Parkway
Building P, 3rd Fl
Richmond, CA 94804
General number (510) 620-5757
Toll-free lead information line in CA (866) 627-1587 (leave message)
http://www.cdph.ca.gov/programs/olppp

University-based Occupational and Environmental Health Clinics

Irvine	(949) 824-8641 UCI
Los Angeles	(310) 794-8144 UCLA
	(888) 258-2590 Drew University
San Diego	(619) 471-9210 UCSD
San Francisco	(415) 885-7580 UCSF
Sacramento	(530) 752-1281 UC Davis

Cal/OSHA Consultation Service

Free health and safety consultation for employers
Headquarters (800) 963-9424
http://www.dir.ca.gov/dosh/consultation.html

Cal/OSHA Compliance Regional Offices

Santa Ana	(714) 558-4451
Van Nuys	(818) 576-7451
Sacramento	(916) 263-2800
Santa Rosa	(707) 576-2388

http://www.dir.ca.gov/dosh/Enforcementpage.htm

Childhood Lead Poisoning Prevention Branch (CLPPB)

California Department of Public Health
Richmond, CA (510) 620-5600
http://www.cdph.ca.gov/programs/clpbb

Key Resource for Further Reading

Kosnett M, Wedeen R, Rothenberg S, Hipkins K, Materna B, Schwartz BS, Hu H, Woolf A. (2007). Recommendations for Medical Management of Adult Lead Exposure. Environmental Health Perspect, 115(3):463-471. http://www.ehponline.org/members/2006/9784/9784.html

FOOTNOTES

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Resources

Toll-free to California callers.

- **For information about lead safety: (866) 627-1587**
- **For information about other workplace hazards: (866) 282-5516**
- **California Relay Service: (800) 735-2929 or 711**
- **www.cdph.ca.gov/programs/ohb**

OLPPP
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Occupational Health Branch
California Department of Public Health
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Richmond, CA 94804

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