

ENVIRONMENTAL  
HEALTH  
ABSTRACTS &  
BIBLIOGRAPHY

August 1978

focus:  
LEAD  
POISONING

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE - PUBLIC HEALTH SERVICE  
CENTER FOR DISEASE CONTROL, ATLANTA, GEORGIA 30333

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE  
PUBLIC HEALTH SERVICE/CENTER FOR DISEASE CONTROL  
BUREAU OF STATE SERVICES/ENVIRONMENTAL HEALTH SERVICES DIVISION

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## GENERAL

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### Recommendations for the Prevention of Lead Poisoning in Children

*National Academy of Sciences, National Research Council, Committee on Toxicology—2101 Constitution Avenue, Washington, DC 20418. NUTR REV 34(11): 321-7, Nov 1976.*

This report, prepared for the Consumer Product Safety Commission, summarizes current research knowledge on the adverse effects of lead, the dosage needed to produce adverse effects, the estimated lead intake for child with pica for paint, and the lead content of currently available household paints.

The Committee was unable to determine that 0.5 percent lead in paint is safe, due to the unavailability of adequate studies. Among other conclusions and recommendations are: (1) total daily lead exposure for 1- to 5-year-old children should not exceed levels sufficient to raise blood level concentration above 30  $\mu\text{g Pb/dl}$ ; (2) a level not to exceed 0.06 percent lead in the final dried product of paint be set for regulatory purposes; (3) lead content of paint or coatings on infant toys or furniture should not exceed 0.06 percent lead and food commonly fed to infants should contain lowest practical FDA-determined level of lead; (4) future research should focus on properly designed animal studies simulating conditions found in a young child, the relationship between dose and effect on human infants less than 12 months of age, and the dose-response relationship of lead in the 1- to 5-year-age group.

### Child Health and Environmental Lead (Editorial)

*Anonymous. BR MED J 1 (6056): 255-6, Jan 29, 1977.*

Overt lead poisoning in children is uncommon in Britain. In addition to a source of lead, the affected child must be at a specific stage in development for lead poisoning to occur. Restricting the use of lead compounds in the home environment may prevent much lead poisoning, but the question remains of whether environmental lead—in air, dust, and water—produces subclinical toxicity. Raised blood lead concentrations have been found in adults (though not in children) exposed to automobile exhaust fumes. Although subtle impairment of fine motor or perceptual skills and other minor effects are possible, overall evidence suggests that environmental lead does not have a major effect on the intellectual or behavioral development of British children. Measures aimed at perinatal prevention of the main causes of neurological handicaps in children are more likely to be cost-effective than attempts to reduce environmental lead exposure, but further studies are justified.

### Child Health and Environmental Lead (Letter)

*P.J. Landrigan and E.L. Baker—Bureau of Epidemiology, Center for Disease Control, Atlanta, GA 30333. BR MED J 1 (6064): 836, Mar 26, 1977.*

The *British Medical Journal's* leading article on this subject [see previous abstract] is a selective and incomplete review of a complex topic. The studies cited, which found no relation between low-level lead exposure and neuropsychological functioning, are questionable because of the inclusion of children with normal blood lead levels in the "lead-exposed" groups. Recent studies not cited in the article indicate that low-level increased lead absorption is capable of producing neurological change in children. [EDI-

**TOR'S REPLY:** Inclusion of children with normal blood lead levels in "lead-exposed" groups is desirable in population studies. Selection of "lead-exposed" groups on the basis of blood lead levels is likely to lead to bias, as shown in the recent studies cited by Drs. Landrigan and Baker. Conclusions of the leading article stand.]

### Is Lead Poisoning Still a Problem?

*J.J. Chisolm, Jr.—Baltimore City Hospital, Baltimore, MD 21224. CLIN CHEM 23(2 PT. 1):252-5, Feb 1977.*

**Author's abstract:** Today, health professionals are concerned about whether asymptomatic or mildly symptomatic increases in lead absorption in preschool children is one of the important factors causing minimal brain dysfunction, which only becomes evident later during the school years. This concern arises, in part, because current screening data show that 5 to 10 percent of the children tested recently in the United States have a degree of increase in lead absorption sufficient to cause metabolic derangement in heme synthesis, but insufficient, with rare exception, to cause classical acute clinical symptoms of plumbism. These screening data are disturbing because similar increases in lead absorption in suckling (but not older) experimental animals have been shown in some studies to be followed by the delayed appearance of subtle deficits in learning ability and aberrations in behavior. Derangement of hemoglobin synthesis is the first adverse effect of increased lead absorption now detectable. Intervention on the basis of the first or critical effect of a toxic agent before more serious effects occur has advantages from the viewpoint of preventive medicine. Current CDC guidelines for prevention of childhood lead poisoning are based on this concept and recommend the use of micro-scale erythrocyte protoporphyrin tests in conjunction with micro blood lead tests for early detection of children with disturbed heme synthesis caused by lead.

### History and Background of Protoporphyrin Testing

*R.F. Labbe—Department of Laboratory Medicine, University of Washington, Seattle, WA 98195. CLIN CHEM 23(2 PT. 1):256-9, Feb 1977.*

**Author's abstract:** Lead intoxication was first associated with increased coproporphyrin excretion almost 100 years ago; but not until the 1930's were abnormalities in blood protoporphyrin detected. These later findings have been interpreted as an inhibition by lead of iron incorporation into protoporphyrin during heme synthesis. The testing and application of this hypothesis had to await three more decades of research during which porphyrin/heme biosynthesis was elucidated, control of the pathway was intensively studied, and methodology was greatly improved. The heme biosynthetic pathway is uniquely affected by lead at several sites. These toxic effects can be manifested as increased coproporphyrin and  $\delta$ -aminolevulinic acid excretion, decreased erythrocyte  $\delta$ -aminolevulinic acid dehydratase activity, and increased erythrocyte protoporphyrin concentration, all of which have been used and promoted as diagnostic tests for lead intoxication. Among these, the last appears to be becoming the test of choice. The historical background of this development is discussed from a biochemical viewpoint.

### Relation Between Quantities of Lead Ingested and Health Effects of Lead in Humans

*K.R. Mahaffey—Division of Nutrition, Food and Drug Administration, U.S. Department of Health, Education and Welfare, Washington, DC 20204. PEDIATRICS 59(3):448-55, Mar 1977.*

**Author's abstract:** Major metabolic effects of lead are briefly reviewed and available data on quantitative relationships between lead ingestion and development of toxicity in adults and children are discussed. Levels of lead ingestion producing clinical toxicity in adults are compared with normal levels of exposure. For children, comparison of levels of lead ingestion and quantities of lead producing toxic effects is not currently possible, as information on levels of lead producing clinical toxicity appears to be highly variable on the basis of the small amount of data available. However, recommendations on tolerable levels of lead exposure for children [less than 100  $\mu\text{g}/\text{day}$  for infants under 6 months, and less than 150  $\mu\text{g}/\text{day}$  for children between 6 months and 2 years] are proposed, based on estimates of lead exposure for children having normal and elevated body burdens of lead.

### Lead-Poisoning Prevention Under Attack (Letter)

*H.L. Needleman and J.W. Graeff—Children's Hospital Medical Center, Boston, MA 02115. N ENGL J MED 296(10):579, Mar 10, 1977.*

The Massachusetts Lead Paint Poisoning Prevention Act of 1971 was an important step toward the elimination of this man-made, preventable disease. Under this law, 100,000 children had blood tests last year; 11,000 were found to have undue lead absorption. Two thousand homes were inspected, and 700 deleaded. Because of the opposition of some landlords and realtors, a large number of bills have been filed with the legislature, most of which would weaken the law in the critical area of housing sanitation. Physicians concerned over the weakening of this public-health law will want to communicate this to their legislative representatives.

### Our Children's Daily Lead

*M.A. Wessel and A. Dominski—878 Howard Avenue, New Haven, CT 06519. AM SCI 65(3):294-8, May-Jun 1977.*

Lead poisoning, known since ancient times, remains a widespread, underestimated, and preventable danger. Pioneers in the recognition of the harmful effects of lead such as George Baker, Benjamin Franklin, and Alice Hamilton were often unheeded or opposed, but have now been vindicated.

Experimental data has demonstrated that, even before clinical symptoms appear, blood lead concentrations can impair cognitive, verbal, perceptual and motor skills, and may have numerous other deleterious effects. Lead is ingested through paint chips, house dust, and common household items. Significant amounts of lead are absorbed into the body with the air we breathe, with automobile emissions by far the greatest and most dangerous source.

In our society, there are complex forces preventing the elimination of lead poisoning. Automobile manufacturers and gasoline producers have challenged and delayed EPA efforts to regulate lead in gasoline. The seriousness of subclinical lead poisoning has not been fully recognized in official circles. To avoid disastrous conse-

quences, technological practices must be revised to limit drastically the production and release of toxic substances.

### Childhood Lead Poisoning in Arkansas

*R.R. Blackwood—Division of Childhood Blood Lead Screening, Arkansas Department of Health, 4815 West Markham, Little Rock, AR 72205. J ARKANSAS MED SOC 74(1):77-8, Jun 1977.*

The existence of childhood lead poisoning in Arkansas has been confirmed by the activities of the Arkansas Childhood Blood Lead Screening Program. Fourteen counties were calculated to have elevated lead level rates of five percent or higher. Door-to-door canvassing is done within these designated high-risk areas. Based on blood lead and erythrocyte protoporphyrin measurements, children are divided into four risk categories to determine the urgency of medical and environmental management. Chelation therapy is initiated for children with confirmed cases of lead poisoning; other children are subject to careful monitoring or routine screening according to risk. The Health Hazards Investigator inspects all dwellings where cases of elevated blood lead levels are found. One of the greatest contributions of the Blood Lead Screening Program has been to make the medical profession and others aware of the existence of this disease in the city and rural populations of Arkansas.

### Lead-contaminated Health Food. Association with Lead Poisoning and Leukemia

*W.H. Crosby—Division of Hematology, Scripps Clinic, 1666 N. Torrey Pines Road, La Jolla, CA 92037. JAMA 237(24):2627-9, Jun 13, 1977.*

Author's abstract: A doctor prescribed a dietary supplement prepared from powdered animal bone for a young woman with dysmenorrhea. Severe lead poisoning developed while she was taking the powder, which was shown to be contaminated with lead. The diagnosis eluded more than 20 physicians and was finally made by the patient herself. The Food and Drug Administration, informed of the contamination, declined to take action, stating that a food supplement is neither a food nor a drug and, besides,

there are no maximal limits for heavy-metal contamination of foods and drugs. [Recently, however, the office of Nutrition and Consumer Services, FDA, formally stated: "The regulatory approaches to both dietary supplements and heavy metals in foods are crystallizing in a far more clear manner than was the case 5 to 10 years ago. We are incorporating 'health food' issues into our FY 77 and 78 compliance programs, including the bone-meal-and-heavy-metal matter."]

### **Childhood Lead Poisoning in North Carolina: Experience in Wilmington**

*S.H. Gehlbach, B. West, J. Morris, et al—1012 Broad Street, Durham, NC 27705. NC MED J 38(7):383-6, Jul 1977.*

Authors' abstract: In July, 1976, the blood lead and free erythrocyte protoporphyrin (FEP) were measured in 240 children, residents of New Hanover County, aged 1 to 6 years. Complete data from 235 subjects showed that 35 (15%) had elevations in blood lead and FEP. Therapeutic chelation was advised for seven who had extreme elevations and diagnostic chelation with calcium disodium ethylene diamine tetraacetate (EDTA) was done when moderate elevation was found in four instances. These 11 children, from eight households, were treated and the presence of excess body lead confirmed. Sixty-nine dwellings frequented by 35 children were surveyed; 42 (61%) had painted surfaces which yielded excess lead. Subclinical lead intoxication in children is a problem in North Carolina and must be approached through medical screening and therapy and by defining and modifying environmental hazards.

### **Gasoline Sniffing and Tetraethyl Lead Poisoning in Children**

*R.L. Boeckx, B. Postil, and F.J. Coodin—Health Sciences Centre, 685 Bannatyne Avenue, Winnipeg, Manitoba R3E 0W1, Canada. PEDIATRICS 60(2):140-5, Aug 1977.*

Authors' abstract: Two cases of acute organic lead poisoning following gasoline sniffing, with one death, are reported. Signs of lead encephalopathy with elevated blood lead levels and markedly decreased levels of erythrocytic delta-

aminolevulinic dehydratase (ALAD) were demonstrated. Erythrocytic ALAD activity was used as a screening test for the detection of tetraethyl lead (TEL) poisoning in a group of 43 children who were presumed gasoline sniffers. Their mean ALAD activity was 190 units compared to a mean of 538 units for a control group. A survey of schoolchildren in another isolated community revealed that 59 percent had decreased ALAD activity, which correlated well with a history of gasoline sniffing. Only 5 percent of the children had blood lead levels over 40  $\mu\text{g}/\text{dl}$ . The two surveys herein reported suggest that there may be large numbers of children living in isolated communities who are suffering from TEL poisoning as result of gasoline sniffing. This constitutes a major medical, public health, and social problem heretofore virtually unrecognized.

### **Quantities of Lead Producing Health Effects in Humans: Sources and Bioavailability**

*K.R. Mahaffey—Division of Nutrition, Bureau of Foods, Food and Drug Administration, Washington, DC 20204. ENVIRON HEALTH PERSPECT 19:285-95, Aug 1977.*

This article reviews the literature on the sources of lead intake, the usual versus the toxic-producing levels of lead ingestion and lead inhalation in adults and children, and the other factors which affect susceptibility to lead.

Food, the major source, along with air and water provide the usual exposure to lead. The average intake of lead from these sources apparently produces no adverse health effects. The sources of unusual lead exposure in children are most commonly urban street dirt, house dust, and paint.

Several estimates have been made of the common levels of lead exposure for adults, the amount of lead ingested that raises blood lead levels, and the amount of inhaled lead which is absorbed. Children apparently retain a greater percentage of lead than adults, but the normal, tolerable, and toxic levels of lead exposure for children are not clearly established.

Organic lead compounds are highly toxic compared to inorganic lead compounds. It has not been determined which inorganic compounds are most likely to have toxic effects, nor

whether other components in the diet, such as milk, increase or decrease lead absorption in humans. Factors such as minerals, vitamins, fat and protein content in the diet have been found, however, to influence amounts of lead absorbed and the distribution of lead within the body.

### Indices of Potential Lead Hazard

*H.S. Posner—Office of Health Hazard Assessment, National Institute of Environmental Health Sciences, P. O. Box 12233, Research Triangle Park, North Carolina 27709. ENVIRON HEALTH PERSPECT 19:261-84, Aug 1977.*

Author reviews the literature on the assessment, by means of biochemical methods on body fluids and tissues, of individual and group health hazards due to lead. Lead concentration in body fluids, enzyme activities, abnormal concentrations of some metabolic intermediates, evidence of lead exposure, and overt signs and symptoms can be used to provide an early line of defense against the harmful effects of lead intoxication.

The author discusses the use and abuse of some key terms in the literature: the distinctions between "normal," "reference," "discrimination," and "decisive" values; "critical" and "sub-critical" effects, and "critical site." Studies on the concentration of lead in whole blood, erythrocytes, plasma, serum, soft tissue, bone, and urine are discussed extensively. The causes and extent to which bound lead is redistributed within the body are pointed out. Lead also affects enzyme activities and is responsible for the accumulation of metabolic intermediates in blood and urine. These studies are described. Briefly enumerated are the clinical signs and symptoms that have been noted in adults and children with lead toxicity.

### Lead Poisoning in South Carolina

*N.H. Whitlock, J.R. Reigart, and L.E. Priester. J SC MED ASSOC 73(8):378-80, Aug 1977.*

City and state screening programs over the past 5 years have demonstrated that lead poisoning is a problem of epidemic proportions in the Charleston area, and may be a serious problem in older sections of the cities in other areas of

South Carolina. Under a 3-year grant administered by the Medical University of South Carolina (MUSC), 23 percent of 4,005 children screened in the city of Charleston were found to be experiencing potentially hazardous lead exposure. The seriousness of these results led to the initiation of a statewide program in 1975, also administered by MUSC in cooperation with the South Carolina Department of Health and Environmental Control. In each municipality where screening is conducted, meetings are held with local health departments to determine the location of children at high risk because of age, socioeconomic status, and conditions of housing. Screening clinics and door-to-door screening follow. Children are classified according to CDC standards of risk, and activities aimed at educating parents and inspecting and improving the condition of the child's environment are carried out. In the first year of statewide testing, 4,456 children were screened; 21 percent had elevated blood lead levels, with the highest percentages in Charleston and Columbia. These preliminary findings suggest a problem with major public health implications in South Carolina.

### Lead in the Blood of California Children

*J.J. Wesolowski, Z. Penton, R. Graul, et al—Air and Industrial Hygiene Laboratory, California Department of Health, 2151 Berkeley Way, Berkeley, CA 94704. WEST J MED 127(3):271-3, Sep 1977.*

From authors' summary: Although elevated lead levels in children have been shown to exist in cities in the East and Midwest, it had been generally believed that no significant problem existed in the western United States. This paper presents data from a lead screening program which utilized a dual test in which both lead and erythrocyte protoporphyrin were measured. The data show that children with elevated lead levels may be found in California, particularly in an area of southeast Los Angeles, where 14 to 23 percent of the 1,239 children screened had blood lead levels greater than 30  $\mu\text{g}$  per 100 ml of whole blood, simultaneously with erythrocyte protoporphyrin levels greater than 60  $\mu\text{g}$  per 100 ml. [Results for the counties of Contra Costa and Alameda were between 2 and 4 percent and between 6 and 8 percent respectively.]

### Is Airborne Lead from Combustion of Leaded Gasoline a Possible Health Hazard?

W.L. Yu, S.A. Vislay, and R.E. Edwards—Southern California Permanente Medical Group, 9985 Sierra Avenue, Fontana, CA 92335. *CLIN PEDIATR* 16(9):791-4, Sep 1977.

Authors' summary: Persistent exposure to automobile fumes, even when sufficiently high to cause recurrent smog, does not raise the blood lead of children and adults under such exposure to abnormally high levels. The average blood lead levels of 277 individuals of all ages tested at the Kaiser Foundation Hospital in Fontana, California, was 20  $\mu\text{g}/100\text{ ml}$  (range 6 to 44  $\mu\text{g}$ ). This suggests that the currently accepted normal upper limit which is 40  $\mu\text{g}/100\text{ ml}$  blood, may be too high. Of pediatric interest is that blood lead levels of mothers and newborns at the time of birth are essentially identical.

### Exposure to Lead: Sources and Effects

H.L. Needleman—Children's Hospital Medical Center, 200 Longwood Avenue, Boston, MA 02115. *N ENGL J MED* 297(17):943-5, Oct 27, 1977.

Recently, many new sources of lead in the human environment have been recognized, and data have been presented which suggest that biochemical functions and neuropsychological performance can be affected by body lead burdens below those which produce clinical symptoms. Biochemical changes associated with lead, especially along the heme pathway, have been demonstrated at blood lead levels of 20  $\mu\text{g}/\text{dl}$  and even lower.

A controversial and crucial question is whether lead levels below those producing frank encephalopathy result in lesser forms of brain injury. The close association of lead exposure with poverty and its attendant troubles, and the difficulties in clinically detecting lead poisoning during the peak exposure in early childhood and in reliably measuring past exposure in older children make the answer difficult. Some researchers have found neuropsychological defects in children with low exposure, others have not. The effects of lead exposure during pregnancy are also matters of concern.

Removal of lead from housing, air, dust, and other environmental sources continues to be an urgent public health goal. The cost of this endeavor must be measured against the value placed on the optimum development of the human brain.

### Lead Effects Among Secondary Lead Smelter Workers with Blood Lead Levels Below 80 Micrograms/100 ML

R. Lilis, W.E. Blumberg, A. Fischbein, et al—Environmental Sciences Laboratory, Mount Sinai School of Medicine, 1 Gustave L. Levy Place, New York, NY 10029. *ARCH ENVIRON HEALTH* 32(6):256-66, Nov-Dec 1977.

Authors' abstract: A subgroup of workers from a secondary lead smelter was defined to include those with blood lead levels not exceeding 80  $\mu\text{g}/100\text{ ml}$  and with no past history of elevated blood lead. Central nervous system symptoms (tiredness, sleeplessness, irritability, headache) were reported by 55 percent of the group and muscle and joint pain by 39 percent. Zinc protoporphyrin (ZPP) levels were elevated in 71 percent of cases. Low hemoglobin levels (less than 14 gm/100 ml) were found in more than a third of the workers. While bun and creatinine were mostly in the normal range, there was nevertheless a correlation between ZPP and both bun and creatinine. Reduced nerve-conduction velocities were present in 25 percent of the group; this was not significantly different from findings in a control group. The data indicate that a blood lead level of 80  $\mu\text{g}/100\text{ ml}$  is an inappropriate biological guide in the prevention of lead disease.

### Generalized Saturnine Paralysis. Discovery of a Double Congenital Disease: Glucose-6-Phosphate Dehydrogenase Deficiency (New Variant) and Distal Tubular Acidosis (French)

F. Nouailhat, J.C. Kaplan, Y. Guidicelli, et al—Reanimation et Urgences Medicales, CHI Leon Touhadjian, F 78303 Poissy. *ANN MED INTERNE* 128(11):827-36, Nov 1977.

English summary: A case of severe lead poisoning with hemolytic anemia, extensive polyneuropathy and arterial hypertension is reported

in a patient for whom G-6-P-D deficiency and renal tubular acidosis were discovered. Both traits were present in his family. Incomplete regression of paralysis and persistent biological abnormalities after chelating treatment were demonstrative of heavy saturnine load even though the toxic exposure was brief. The role of the two deficiencies in the mechanism of intoxication is discussed: facilitation of hemolysis by enzymopathy and bone lead redistribution result-

ing from osteolysis probably due to the tubulopathy. The authors emphasize the fact that thorough and serial biological investigation is essential in the discovery of factors which may precipitate lead poisoning, as well as in the determination of followup criteria of efficient toxic epuration with sufficient delay. Typing of the enzyme has led to the identification of a new variant of glucose-6-phosphate dehydrogenase deficiency.

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## DIAGNOSIS AND SCREENING

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### Free Erythrocyte Protoporphyrin as an Indicator of the Biologic Effect of Lead in Adult Males. III. Behavior of Free Erythrocyte Protoporphyrin in Workers with Past Lead Exposure

L. Alessio, P.A. Bertazzi, O. Monelli, and F. Toffoletto—*Institute of Occupational Health, University of Milan, Via S. Barnaba 8, I-20122 Milano, Italy. INT ARCH OCCUP ENVIRON HEALTH 38(2):77-86, Dec 15, 1976.*

The relationship between FEP and the indicators of internal dose (PbB, PbU, PbU-EDTA) was studied in 67 males who had left jobs exposing them to lead more than 12 months previously. Correlations between FEP and PbB ( $r=0.51$ ) and FEP and PbU ( $r=0.36$ ) were lower than such correlations in currently exposed subjects ( $r=0.90$  and  $r=0.88$  respectively). A high correlation was found between PbU-EDTA and FEP in subjects with past exposure ( $r=0.76$ ) even though more modest than a group of currently exposed subjects ( $r=0.89$ ). This last result suggests that FEP remains at high levels for long periods due to direct inhibition of heme synthesis by lead released from tissue deposits, and that FEP is a valid test for predicting the amount of lead storage, even a long time after cessation of exposure.

### Measurement of Lead Content of Children's Teeth *In Situ* By X-ray Fluorescence

P. Bloch, G. Garavaglia, G. Mitchell, and I.M. Shapiro—*Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia, PA. PHYS MED BIOL 22(1):56-63, Jan 1977.*

Authors' abstract: The central nervous system of young children is particularly sensitive to neu-

rological damage due to excessive lead exposure. The lead stored in a tooth is permanent and related to the quantity of ingested lead. The lead is assayed by measuring the characteristic radiation from lead in a tooth *in situ* irradiated with gamma rays from a cobalt-57 source. The sensitivity of the method is adequate to measure lead levels commonly associated with environmental background. The X-ray exposure to the tooth necessary for this determination is approximately one tenth of that required for a routine dental examination.

### Erythrocyte Porphobilinogen Synthase (Delta-Aminolaevulinatase) Activity: A Reliable and Quantitative Indicator of Lead Exposure in Humans

R.A. Mitchell, J.E. Drake, L.A. Wittlin, and T.A. Rejent—*Molecular Biology Laboratory, State University College, Fredonia, NY 14063 CLIN CHEM 23(1):105-11, Jan 1977.*

Authors' abstract: We assessed optimal conditions for assay of porphobilinogen synthase (EC 4.2.1.24) activity in human blood containing abnormally high concentrations of lead.  $Zn^{2+}$  and  $-SH$ , both required for complete activation of the enzyme, had additive effects. Using a modified method based on these studies, we found blood lead concentration to be strictly proportional to  $\ln$  (activated/nonactivated) enzyme activity. One brand of commercially available "lead-free" tubes contained a substance that interfered with this relationship. *In vitro* studies, with the modified assay, showed ALAD to be activated by low concentrations but inactivated by high concentrations of  $Hg^{2+}$ ,  $Cd^{2+}$ , and ethylenediaminetetraacetate. We found no genetically influenced differences among unexposed individuals when  $\ln$  (activated/nonactivated) enzyme

activities were compared. The technique is suitable for use in screening for lead poisoning in humans.

### The Hematofluorometer

W.E. Blumberg, J. Eisinger, A.A. Lamola, and D.M. Zuckerman—Bell Laboratories, Murray Hill, NJ 07974. *CLIN CHEM* 23(2 PT. 1):270-4, Feb 1977.

Authors' abstract: A portable filter fluorometer, the hematofluorometer—which utilizes "front face" optics, internal standards, and digital computation capabilities—has been specifically designed for the rapid (~5 s) assay of erythrocyte zinc protoporphyrin in unprocessed blood. A small (unmeasured) drop of blood, such as is obtained from a finger puncture, is placed on a disposable cover slip and inserted in the sample holder of the instrument. The operator pushes the holder, which also holds the permanent blank and standard, into the instrument. Zinc protoporphyrin concentration is automatically and instantaneously computed and the value is displayed on a digital readout as micrograms of zinc protoporphyrin per deciliter of blood for some standard hematocrit. No calibration adjustment need be performed by the operator. The hematofluorometer is designed for "field" use as well as for laboratory assays.

### Application of the Zinc Protoporphyrin (ZP) Test as a Monitor of Occupational Exposure to Lead

M.M. Joselow and J. Flores—Department of Preventive Medicine and Community Health, College of Medicine and Dentistry of New Jersey, Newark, NJ 07103. *AM IND HYG ASSOC J* 38(2):63-6, Feb 1977.

Zinc protoporphyrin, the predominant abnormal metabolite appearing in whole blood due to chronic lead absorption, can now be assayed fluorometrically in diluted whole blood simply, quickly, and with great sensitivity. ZP content increases rapidly at blood lead levels above 50  $\mu\text{g}/100\text{ ml}$  and the correlation coefficient for the direct relationship between log ZP and lead content was quite good ( $r=0.8$ ) in a group of male workers occupationally exposed to lead. Since ZP assays are more directly indicative of meta-

bolic damage, less subject to contamination, and simpler, cheaper, and quicker, they should be seriously considered as the biochemical test of choice in monitoring workers exposed to lead.

### Free Erythrocyte Porphyrins in the Detection of Undue Absorption of Pb and of Fe Deficiency

S. Piomelli—Division of Pediatric Hematology, New York University Medical Center, 550 First Avenue, New York, NY 10016. *CLIN CHEM* 23(2 PT. 1):264-9, Feb 1977.

Author's abstract: A fluorometric assay for free erythrocyte porphyrins (FEP) is described in detail, the direct test being used for the analysis of blood specimens collected with anticoagulants and the spot test for analysis of blood specimens collected on filter paper. [The measurement of hemoglobin on filter paper is explained.] A method for determining the amount of blood absorbed by different lots of filter paper is described.

### The Lead Line in Clinical Medicine

K.S. Martin. *CENT AFR J MED* 23(3):55-6, Mar 1977.

Lead poisoning, usually resulting from industrial exposure to lead compounds, can produce a variety of symptoms, some of which closely mimic the acute abdomen, myopathy and neuropathy, including encephalopathy. Identification of the lead line on the gingival margin can be vitally important in distinguishing lead poisoning from other medical emergencies as three recent case histories show. The lead line, which is formed by the subepithelial deposition of insoluble lead sulphide, appears as a stippled, blue-black line, one millimeter away from the junction of the gingival epithelium and the base of the tooth (gingival margin). Lead sulphide is produced when soluble lead salts in the blood react with bacteria-produced hydrogen sulphide at the gum line. The tooth need not be carious. Although the presence of the lead line indicates exposure to lead and not necessarily toxic blood levels, because of the likely delay in ascertaining blood lead level, treatment should start immediately on the acutely ill patient with lead lines and known exposure to lead.

### **A Simple Fluorometric Assay of Protoporphyrin in Erythrocytes (EPP) as a Screening Test for Lead Poisoning**

*A.P. Orfanos, W.H. Murphey, and R. Guthrie—(Dr. Guthrie) SUNYAB/Bell Facility, PO Box U, Station B, Buffalo, NY 14207. J LAB CLIN MED 89(3):659-65, Mar 1977.*

Authors' abstract: A simple microfluorometric procedure for the measurement of protoporphyrin in erythrocytes (EPP) is described. The technique, which can be performed in less than 4 minutes with portable equipment, utilizes 40  $\mu$ l of capillary blood and only one reagent (94% acidified ethanol) for the extraction. The results obtained by this micromethod are in close agreement with those of the ethyl acetate/hydrochloric acid double-extraction methods. The EPP concentration increases markedly when the blood lead level is increased, and the test can be used to screen children for lead poisoning. This new micromethod also gives reproducible results when dried blood spots on filter paper are used instead of liquid blood.

### **Lead Screening by Family Physicians**

*J. Froom—Family Medicine Program, University of Rochester School of Medicine and Highland Hospital, 885 South Avenue, Rochester, NY 14620. J FAM PRACT 4(4):631-3, Apr 1977.*

Author's abstract: Blood lead level tests, by the finger-prick micromethod, were given to 333 children in a primary care practice. On initial testing, 18.6 percent of children had lead levels between 30 and 39  $\mu$ g/100 ml and 10 percent had lead levels of 40  $\mu$ g/100 ml or greater. In the latter group, only 2.7 percent had levels in that range when retested with venous blood samples. Socioeconomic status, as determined by census tract residence, correlated with evidence of undue lead absorption. Of the children tested from socioeconomic Group I (I is highest), 3.4 percent were affected, as opposed to 60.0 percent of the children residing in Group V census tracts.

### **Filter Paper-Disc Method for the Determination of Zinc Protoporphyrin in Blood**

*M.M. Joselow and J. Flores—Department of Preventive Medicine and Community Health, College of Medicine and Dentistry of New Jersey, Newark, NJ 07103. HEALTH LAB SCI 14(2):129-32, Apr 1977.*

Authors' abstract: Zinc protoporphyrin, an abnormal metabolite resulting from undue lead absorption, can be quantitatively determined in blood that has been spotted and dried on filter paper. This procedure, which yields values that correlate well ( $r=0.96$ ) with those obtained by direct determination in whole blood, offers advantages in convenience of collection, storage, and transportation that recommend it for field use. The light sensitivity of the zinc protoporphyrin, however, mandates that the specimens be protected from excessive light exposure until analyzed.

### **Diagnostic Methods in Iron Deficiency States. Comparative Data on Free Protoporphyrins of Erythrocytes in Iron Deficiency States and in Thalassemia (Italian)**

*L. Pinto, L. Esposito, and B. Nobili. PEDIATRIA 85(2):291-310, Jun 30, 1977.*

English summary: Iron deficiency anemia may be considered as the last step of a series of events through which the organism passes from normal erythropoiesis with adequate iron reserves toward the exhaustion of iron reserves and then to the inefficiency of erythropoiesis. An important goal appears to be identification of the exhaustion of iron reserves before this condition has led to clinical manifestations. The authors review the modern methods for such a diagnosis, namely the assay of ferritin, of transferrin, of transferrin percent saturation and of FEP.

They report their personal experience on the behavior of FEP in cases of iron deficiency anemia and in cases of thalassemia. Mean FEP in normal subjects has been found to be  $54 \pm 17$   $\mu$ g/100 ml while an increase has been observed in preclinical iron deficiency ( $130 \pm 20$   $\mu$ g/100 ml) and even more in iron deficiency anemia ( $188 \pm 79$   $\mu$ g/100 ml). In heterozygous for thalassemia FEP has been found to be within the nor-

mal range ( $53 \pm 19 \mu\text{g}/100 \text{ ml}$ ) while in thalassemia major FEP was slightly elevated ( $73 \pm 23 \mu\text{g}/100 \text{ ml}$ ). The lack of increase of FEP in thalassemia is interpreted as due to an inhibition exerted by heme on metabolic steps leading to protoporphyrin IX. On the basis of this research the diagnostic importance of protoporphyrins in iron deficiency clearly appears.

#### Experimental Use of ESA 4000 Hematofluorometer in Normal Subjects and in Workers Occupationally Exposed to Lead (Italian)

A. Gobbi, R. Grisler, and F. Toffoletto. *MED LAV 68(4):303-7, Jul-Aug 1977.*

English summary: One hundred and fifty subjects (100 men and 50 women) not occupationally exposed to lead and with good sanguification, were given tests with an ESA 4000 Hematofluorometer. The values obtained, expressed as micrograms of protoporphyrin IX/100 ml whole blood, were: mean = 28.7 for both sexes; upper limit within normal range ( $m + 2s$ ) = 40.2 for the men and 37.4 for the women. In a group of 112 workers exposed to lead absorption, much higher values were observed, up to a maximum of  $290 \mu\text{g}/100 \text{ ml}$  whole blood. This instrument can therefore well replace the previous analytical methods based on extraction techniques.

#### Biochemical Methods for the Detection of Lead Poisoning (German)

W. Kisser—*Institut für Gerichtliche Medizin der Universität Salzburg, Ignaz-Harrerstrasse 79, A-5020 Salzburg, Österreich. ARCH TOXICOL 37(3):173-93, Jul 19, 1977.*

English summary: After a short description of sources of lead poisoning, a review is given of toxicity, absorption, storage and excretion of lead. Afterwards its biochemical effects—especially the influence on the biosynthesis of heme—are treated. Methods for the diagnosis of lead poisoning resulting from these effects—determination of coproporphyrin and delta-aminolevulinic acid excretion in urine, erythrocyte delta-aminolevulinic acid dehydratase activity and erythrocyte protoporphyrin—are discussed in detail.

#### ALAD/EP Ratio as a Measure of Lead Toxicity

T. Beritic, D. Prpic-Majic, V. Karacic, and S. Telisman—*Institute for Medical Research and Occupational Health, Yugoslav Academy of Sciences and Arts, Zagreb, Yugoslavia. JOM 19(8):551-7, Aug 1977.*

Authors' summary and conclusions: In the natural course of the human response to the action of lead, the activities of cytoplasmic ALAD and of mitochondrial ferrochelatase as determined in the peripheral blood, do not seem to follow the same pattern of onset and duration. While the activity of the peripheral erythrocytic ALAD is inhibited rapidly and very early due to the direct action of lead in blood, the inhibition of the medullar erythroblastic ferrochelatase, due to the action of lead in bone marrow and evidenced indirectly by the increase of EP, is "slow" and "late" due to the gradual maturation and gradual release of "EP-marked" mature erythrocytes from the bone marrow into peripheral blood. This is why the EP concentration may continue to increase after all other biologic effects of lead have improved or become no more measurable and long after an external lead exposure has ceased.

Since no interaction seems to exist between the activities of the two enzymes, it has been suggested that their gradients might reflect the magnitude and duration of excessive lead absorption and permit a distinction between the acute and the chronic phases of action of lead.

In a total of 347 subjects attending our department in various stages of, or suspected for lead action, ALAD activity has been investigated coincident with the EP concentration. It is concluded that the use of these tests in conjunction provides not only a reliable diagnostic tool but also an important index showing the approximate magnitude, duration, and the time elapsed since the past or recent exposure.

#### Improved Ethanol Extraction Procedure for Determining Zinc Protoporphyrin in Whole Blood

J.S. Garden, D.G. Mitchell, K.W. Jackson, and K.M. Aldous—*Division of Laboratories and Research, New York State Department of Health, Albany, NY 12201. CLIN CHEM 23(9):1585-9, Sep 1977.*

Authors' abstract: We describe a fluorometric method for determining zinc protoporphyrin in which whole-blood specimens collected in heparin/ethylenediaminetetraacetate are prediluted with water, and zinc protoporphyrin is extracted into ethanol/water (95/5 by vol). The resulting extract has a low absorbance (0.05) at the excitation wavelength (415 nm) of zinc protoporphyrin, and the extraction efficiency is about 33 percent greater than is true for ethyl acetate/acetic acid extraction. When 10  $\mu$ l of whole blood is used, the ethanol extraction procedure with predilution has a detection limit of 40  $\mu$ g of zinc protoporphyrin per liter of whole blood, linear response to at least 100 mg/liter, day-to-day precision of better than 5 percent (CV) over the concentration range 360-2000  $\mu$ g/liter, and

within-run precision of better than 1.5 percent at concentrations exceeding 300  $\mu$ g/liter. Analysis of 143 blood samples by both the ethanol-with-predilution and ethyl acetate/acetic acid extraction procedures yielded the relationship: [erythrocyte protoporphyrin] = 0.75 ( $\pm$ 0.05) [zinc protoporphyrin] - 0.95 ( $\pm$ 1.58) at the 95 percent confidence level, "erythrocyte protoporphyrin" being that measured by the ethyl acetate/acetic acid procedure. Comparison of erythrocyte porphyrin data obtained by calculation from zinc protoporphyrin values and by direct measurement showed no significant difference between the two procedures (Student's *t*-test). The preliminary dilution step is essential for maximum extraction.

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## EPIDEMIOLOGY

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### Increased Lead Absorption with Anemia and Slowed Nerve Conduction in Children Near a Lead Smelter

*P.J. Landrigan, E.L. Baker, Jr., R.G. Feldman, et al—Bureau of Epidemiology, Center for Disease Control, Atlanta, GA 30333. J PEDIATR 89(6):904-10, Dec 1976.*

Authors' abstract: Studies to evaluate the prevalence, sources, and health consequences of lead absorption were conducted among children living near a primary lead smelter. Lead levels in air, soil, and dust were highest at the smelter and decreased with distance. Ninety-nine percent of 1- to 9-year-old children living within 1.6 kilometers had blood lead levels  $\geq 40$   $\mu\text{g}/\text{dl}$ , indicating increased absorption, and 22 percent had levels  $\geq 80$   $\mu\text{g}/\text{dl}$ . The prevalence of lead levels  $\geq 40$   $\mu\text{g}/\text{dl}$  decreased with distance; at 72 kilometers from the smelter it was 1 percent. Erythrocyte protoporphyrin levels increased with blood lead levels: 17 percent of children with lead levels of  $\geq 80$   $\mu\text{g}/\text{dl}$  were anemic. There was no overt neurologic toxicity. Significant negative correlation was found in 202 5- to 9-year-old children between blood lead levels and motor nerve conduction velocity ( $r = -0.38, p < 0.02$ ).

### Lead Intoxication Attributable to Automobile Traffic (German)

*W. Blumer—FMH Allgemeine Medizin, CH-8754 Netstal, Switzerland. PRAXIS 66(19):491-6, Apr 19, 1977.*

English summary: The use of lead-containing gasoline has resulted in an ever increasing lead content in the blood of many humans. By means of the delta-aminolaevulinic-acid test, lead poisoning today can be diagnosed rather

easily. Leaded gasoline does not cause typical symptoms of poisoning, but it induces certain not specifically defined nervous disturbances, such as headaches, nervousness, insomnia, depressive conditions and gastro-intestinal disturbances.

The author's research activities have shown that among persons residing in the immediate vicinity of a busy traffic artery these disturbances occurred much more frequently than among residents of a traffic-free section of the town. After treatment with calcium-edetate (lead-elimination) and with vitamins having an anti-toxic effect, the complaints of these individuals disappeared. At the same time the content of delta-aminolaevulinic-acid became normal and an increasing amount of lead was eliminated through the urine.

During an observation period of 12 years, 11 percent of all persons living adjacent to the traffic artery died of cancer, as against only 1.2 percent of individuals living in the traffic-free section. Almost without exception these patients never before had been treated with calcium-edetate. These data, reinforced by many findings in medical literature, lead to the assumption that lead in automotive gasoline can cause increased incidence of cancer. The soil content of polycyclic carbohydrates along the traffic artery was 12 times greater than in the traffic-free section, and it could be proved that these carbohydrates originated from automotive emissions.

### Unsuspected Sources of Lead Poisoning (Letter)

*C. Rice, R. Lilis, A. Fischbein, and I.J. Selikoff—Mount Sinai School of Medicine, New York, NY 10029. N ENGL J MED 296(24):1416, Jun 16, 1977.*

The study by Baker et al described in the February 3, 1977 issue of the *New England Journal of Medicine* suggests a close association between symptomatic lead poisoning and lead particulates brought home from the workplace. Hygienic measures outlined in that article substantially alleviate the problem of symptomatic lead poisoning in this population, but according to the authors' recent studies, will not entirely solve it. Storing one's clothes in a dirty locker, walking across lead contaminated areas on the way home, and particulate fallout on automobiles parked near the place of work are further possible sources of contamination, so that even with routine precautions, household lead contamination may be an important clinical problem.

#### Heavy Metal Pollution Among Autoworkers. I. Lead

*J. Clausen and S.C. Rastogi—Laboratory of Biochemistry and Toxicology, Institute of Life Science Faculty Natural Sciences, Building 161, University of Roskilde, Roskilde, Denmark. BR J IND MED 34(3):208-15, Aug 1977.*

Authors' abstract: Lead pollution was evaluated in 216 individuals working in 10 garages on the Island of Funen, Denmark and related to data from biochemical and medical examinations. Clinical symptoms were recorded by means of a questionnaire. Increased blood lead levels were found in 59 percent, with 9 percent having above 80  $\mu\text{g}$  lead/100 ml (3.86  $\mu\text{mol}/1$ ) whole blood. Mechanics in eight out of ten garages had significantly increased blood lead levels. A decrease in  $\delta$ -aminolevulinic acid dehydratase (ALAD) activity was associated with increased blood lead levels but the latter were not related to hematological changes, tobacco consumption or to length of service in the trade. Particulate lead air pollution was not the sole cause of increased blood lead levels. Raised lead values were maximal among diesel engine workers who are exposed to high pressure-resistant lubricants containing lead naphthenate. As these workers complained of skin damage, lead absorption may have occurred through the skin. Assay of lead content showed 9290 ppm in gear oil and 1500-3500 ppm in used motor oils.

The data are discussed in relation to the occupational risks in auto repair shops.

#### Lead in Human Blood and in the Environment Near a Battery Factory

*W.J. Elwood, B.E. Clayton, R.A. Cox, et al—reprints from D. Malcom, Chloride Group Ltd, 52 Grosvenor Gardens, London SW1. BR J PREV SOC MED 31(3):154-63, Sep 1977.*

From authors' summary: Samples of blood, air, dust, soil, vegetation, and tap water were examined between 1973 and 1975 to determine whether a large battery factory (with a smelter) was contributing to lead in the environment and to lead absorption by the local population. Mean blood levels in the children of lead workers were about 6  $\mu\text{g}/100$  ml higher ( $P < 0.001$ ) than in otherwise comparable children. Capillary blood samples in wives of lead workers were 1.7  $\mu\text{g}/100$  ml higher ( $P < 0.05$ ) than those of otherwise comparable wives, but venous blood samples from the same subjects showed no significant difference. Lead in dust, soil and vegetation, although variable, decreased in concentration with distance from the factory. This relationship with distance from the factory was not however found in blood lead levels. No consistent effect of distance was found with lead in air, but significantly higher concentrations were recorded at downwind than upwind sites. The blood lead results have been analyzed to assess the influence of domestic factors of possible relevance—such as, lead pipes, car ownership, age of house, etc. The presence of a lead worker in the household appears to outweigh these other factors.

#### A Nationwide Survey of Heavy Metal Absorption in Children Living Near Primary Copper, Lead, and Zinc Smelters

*E.L. Baker, Jr., C.G. Hayes, P.J. Landrigan, et al—(Dr. Landrigan) Environmental Hazards Activity, Cancer and Birth Defects Division, Bureau of Epidemiology, Center for Disease Control, Atlanta, GA 30333. AM J EPIDEMIOLOGY 106(4):261-73, Oct 1977.*

Authors' abstract: Arsenic, lead, and cadmium absorption levels were determined in 1774

children 1-5 years old living in 19 USA towns with primary nonferrous metal smelters. Results were compared with data on 258 children of the same age in three communities without smelters. Increased systemic absorption of arsenic, as reflected by urine arsenic content, was noted in children near 10 of 11 copper smelters. Blood lead levels were also modestly elevated near two copper smelters. Near lead and zinc smelters, elevated levels of lead and cadmium in hair provided evidence of external exposure to these elements. Levels of lead in blood were not, however, elevated near any of three lead smelters and were elevated near only two of five zinc smelters. Blood cadmium levels were high near one lead and two zinc smelters. The apparent sources of exposure (except in one community with elevated levels of arsenic in drinking water) were air, soil, and dust contaminated by smelting operations. While the full biologic significance of these findings is not known, exposure of children to toxic heavy metals emitted by smelters should be reduced to a minimum.

**On the Behavior of Cadmium and Lead in Children with a Different Cadmium or Lead Burden (German)**

*J. Rosmanith, H.J. Einbrodt, and W. Ehm—Lochnerstr. 4-20, D-5100 Aachen. ZENTRALBL BAKTERIOL ORIG B 165(2): 207-25, Oct 1977*

English summary: An epidemiological study of 413 randomly chosen children in age of 2-14 years living in an industrial town is presented. According to their place of residence the children were either burdened with cadmium from a forge or with lead from the traffic. The different burden was reflected not only in the blood lead level but also in blood cadmium level. Both contaminants showed in their separate effects the same behavior. The intensity of the absorption of lead or cadmium respectively influences not only the relationship between blood lead level or blood cadmium level and the other parameters (Pb-H, Pb-U, Cd-H, Cd-U, D-ALA-U), but also the distribution of these parameters.

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## RESEARCH AND EVALUATION

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### Classification of Microcytic Anemia by Fluorometric Analysis of Free Erythrocyte Porphyrins (FEP)

*H.M. Koenig—Hematology Division, Department of Pediatrics, Naval Regional Medical Center, San Diego, CA 92134. ANN CLIN RES 8 Suppl 17:151-5, 1976.*

Author's abstract: Microcytic red blood cells (RBC) occur in iron-deficiency anemia, lead poisoning, and the thalassemia syndromes. Micromeritment of FEP by acid extraction from RBC was performed on RBC of 64 subjects with RBC mean corpuscular volume <78 fl as determined on a Coulter S. FEP was also determined on RBC from 25 nonanemic, normocytic subjects for comparison. The 25 nonanemic subjects, 29 subjects with  $\alpha$ -thalassemia trait and 16 subjects with  $\beta$ -thalassemia trait had FEP <107  $\mu\text{g}/100$  ml RBC. Nineteen microcytic subjects with iron-deficiency anemia had FEP of 185-752  $\mu\text{g}/100$  ml RBC. Hemolysates from 8 lead intoxicated individuals had FEP values similar to those of iron-deficient patients. The fluorescence emission spectra of lysates with high FEP, which were not extracted, were similar in iron deficiency and lead poisoning. The porphyrin that accumulates in these two conditions appears to be zinc protoporphyrin. Micromeritment of FEP can be used to initially classify microcytic anemias into either a disturbance of globin synthesis or a disturbance in heme synthesis. Iron-deficiency anemia and lead poisoning cause accumulation of identical porphyrin and cannot be distinguished by fluorometric analysis.

### Turnover of Erythrocyte Protoporphyrin, with Special Reference to Bovine Porphyria and Iron Deficiency Anemia

*S. Schwartz, N. O'Connor, B.D. Stephenson et al—Department of Medicine, University of Minnesota, Box 291, Minneapolis, MN 55455. ANN CLIN RES 8 Suppl 17:203-12, 1976.*

From authors' abstract: Available data from human subjects suggests that most of the pools of free protoporphyrin in circulating erythrocytes have  $T_{1/2}$  values which range from less than 1 hour to approximately 2 weeks. An exception was observed in two cows with erythropoietic ("congenital") porphyria. Variable ratios of red cell/fecal protoporphyrin concentrations reported in other diseases are also believed to be due largely to  $T_{1/2}$  differences in porphyrin pools.

Recorded fluorescence and excitation spectra of blood showed the single fluorescence band of "free" porphyrin in bloods of normal and porphyric cows and of patients with erythropoietic porphyria, protoporphyrin, and sideroblastic anemia. The 2 band zinc complex spectrum was found, as expected, in blood of subjects with Pb poisoning and Fe deficiency anemia.  $T_{1/2}$  values of 1 to 2 weeks were calculated for red cell protoporphyrin from previously published data of patients with Fe deficiency anemia who were treated effectively with iron.

### Normal Values of Free Protoporphyrin IX Studied in 256 Male Adult Subjects Living in Lombardy (Italian)

*R. Grisler, A. Gobbi, G. Colombo, and R. Colombo. MED LAV 67(2):158-62, Mar-Apr 1976.*

English summary: Using the fluorimetric method, the concentration of free protoporphyrin IX in red blood cells was determined in 256 adult male subjects living in Lombardy not occupationally exposed to lead absorption. Absence of biochemical signs of excessive lead absorption was also checked in these subjects by measuring coproporphyrins or ALA in urine. The results expressed in  $\mu\text{g}/100$  ml red blood cells, were as follows: range: 15-60; mean: 29.5; standard deviation: 8.5; upper limit of normal range ( $m + 1.96 s$ ): 46.1; upper threshold of range limit ( $m + 2.60 s$ ): 51.6; only 8 values were in the range 47-60.

#### Lead Detection and Measurement in Biological Fluids by Means of Anodic Stripping Voltammetry (Italian)

R. Gagliano-Candela, S. Napoli, and T. Gagliardi. *LAV UM 28(3):82-8, May 1976.*

English summary: The authors deal with the anodic stripping voltammetry method for detecting and measuring lead in biological fluids. A comparison was made with the more widely used dithizone method. The mercury-graphite electrode was also checked in respect of both the plating time and the amount of analyses performed. From the results obtained the authors conclude that the anodic stripping voltammetry technique appears to be simpler and more rapid and sensitive than the dithizone method for lead detection and measurement in biological fluids. The former is therefore particularly suitable for laboratories where routine repetitive analyses are performed.

#### Relationship Between Lead Concentration in Blood and Biologic Response for Porphyrin Metabolism in Workers Occupationally Exposed to Lead

K. Tomokuni and M. Ogata—Department of Public Health, Okayama University Medical School, 2-5-1 Shikata, Okayama, Japan. *ARCH TOXICOL 35(4):239-46, Aug 18, 1976.*

From authors' summary: The biologic responses of the heme biosynthesis pathway in male workers moderately exposed to lead are discussed in relation to the concentration of lead in

the blood. Erythrocyte delta-aminolevulinic acid dehydratase (ALA-D) activity was remarkably reduced while erythrocyte protoporphyrin (Proto) was strikingly increased, compared to normal levels. The log of erythrocyte Proto level was closely correlated to the blood lead level and the sensitivity of the Proto test was almost equal to that of erythrocyte ALA-D test. Erythrocyte Proto was remarkably increased even in lead-exposed workers whose ALA excretion into the urine was in the range of normal level.

#### Evaluation of the Iron Status of a Population

J.D. Cook, C.A. Finch, and N.J. Smith—Division of Hematology, Department of Medicine, University of Kansas Medical Center, Rainbow Boulevard at 39th, Kansas City, KS 66103. *BLOOD 48(3):449-55, Sep 1976.*

From authors' abstract: The iron status of a population of 1564 subjects living in the northwestern United States was evaluated by measurements of transferrin saturation, red cell protoporphyrin, and serum ferritin. When only one of these three parameters was abnormal (transferrin saturation below 15%, red cell protoporphyrin above 100  $\mu\text{g}/\text{ml}$  packed red blood cells, serum ferritin below 12 ng/ml), the prevalence of anemia was only slightly greater (10.9%) than in the entire sample (8.3%). The prevalence of anemia was increased to 28 percent in individuals with two or more abnormal parameters, and to 63 percent when all three parameters were abnormal. As defined by the presence of at least two abnormal parameters, the prevalence of iron deficiency in various populations separated on the basis of age and sex ranged from 3 percent in adolescent and adult males to 20 percent in menstruating women. Accuracy of detecting iron deficiency in population surveys can be substantially improved by employing a battery of laboratory measurements of the iron status.

#### Susceptibility of Living Organisms to Lead Poisoning. Part I. The Normal Value of Erythrocyte Delta-Aminolevulinic Acid Dehydratase Activity in Rats and Humans (Japanese)

H. Maruta. *SANGYO IGAKU 19(2):67-74, Mar 1977.*

From English summary: This study was intended to examine some factors influencing the normal ALA-D activities of rats and humans. The ALA-D activity of male Wistar rats was determined in relation to age and the effect of blood drawing was examined. The ALA-D activity of inhabitants in rural and urban districts was also determined.

The results were as follows:

1) The ALA-D activity of intact rats showed  $0.77 \pm 0.09$   $\mu$ moles PBG/h/ml RBC in those at 3 weeks of age,  $0.11 \pm 0.02$  in 9 weeks,  $0.14 \pm 0.06$  in 17 weeks,  $0.15 \pm 0.07$  in 27 weeks, and  $0.19 \pm 0.02$  in 58 weeks. The value of ALA-D activity of rats indicated remarkable decrease before 9 weeks of age, and then became stable up to 58 weeks, though with apparently slight increase. These phenomena kept pace inversely with body weight of rats up to 250 g.

2) Blood drawing gave a marked difference of ALA-D activity between young and adult rats. The ALA-D activity 24-48 hours after blood drawing was elevated considerably in young rats as compared with adult ones.

3) An excellent inverse correlation was found between erythrocyte ALA-D activity and peripheral blood findings of rats. The coefficient of correlation of ALA-D activity with Ht, Hb and RBC value was  $-0.91$ ,  $-0.81$ , and  $-0.78$ , respectively.

4) The ALA-D activity in urban populations was studied in three age groups (6 children, 146 youths, and 20 aged). There were no differences in ALA-D activity by age and sex.

5) The ALA-D activity in rural residents 47 years old and over was examined too. Significant statistical difference of ALA-D activity was observed between males and females ( $p < 0.001$ ).

#### Comparison of Zinc Protoporphyrin and Free Erythrocyte Protoporphyrin in Whole Blood

M.M. Joselow and J. Flores—Department of Preventive Medicine and Community Health, College of Medicine and Dentistry of New Jersey, Newark, NJ. 07103. *HEALTH LAB SCI* 14(2):126-8, Apr 1977.

Authors' abstract: The recent change in emphasis from blood lead to erythrocyte protoporphyrin as the primary diagnostic test for

screening for childhood lead poisoning has made it desirable to develop the quantitative relationship between the two protoporphyrins, free erythrocyte protoporphyrin (FEP) and zinc protoporphyrin (ZP), that are now widely used for screening purposes. ZP was found to be equal to 1.4 EP, thus permitting the measurement of either parameter, and its conversion to the other.

#### Quantitative Determination of Erythrocyte Zinc Protoporphyrin

A.A. Lamola, J. Eisinger, W.E. Blumberg, et al—Bell Laboratories, Murray Hill, NJ 07974. *J LAB CLIN MED* 89(4):881-90, Apr 1977.

Authors' abstract: An elevated zinc protoporphyrin (ZPP) level in blood is indicative of lead poisoning (as well as iron-deficiency anemia) and is the basis for certain fluorometric screening tests. The calibration of such test protocols and instruments requires ways to reliably determine absolute ZPP concentrations in blood. Two such methods are described: one is an ethanol extraction method and the other a fluorometric addition method using detergent hemolyzed blood. A careful determination of the molar extinction coefficient of ZPP gives  $E_m m = 161$  in pyridine. Corrections are offered for a previously published protocol for determining the ZPP concentration from the fluorescence intensity of diluted blood. The choice of units for expressing the ZPP concentration in blood is discussed, as is the absorbance correction in quantitative fluorometry of samples which are not optically thin at the excitation wavelength.

#### Cognitive Evaluation of Children with Elevated Blood Lead Levels

D. Kotok, R. Kotok, and J.T. Heriot—Genesee Health Service, 220 Alexander Street, Rochester, NY 14607. *AM J DIS CHILD* 131(7):791-3, Jul 1977.

Cognitive evaluation of 31 children with elevated blood lead levels ( $61-200$   $\mu$ g/100 ml) was compared with that of a control group of 36 children (blood lead level  $< 40$   $\mu$ g/100 ml) similar in age, sex, race, neonatal condition, socioeconomic status, and presence of pica. Cognitive

functioning was determined by using the multi-dimensional protocol developed by Heriot to evaluate the developmental areas of social maturity, spatial relationships, spoken vocabulary, information-comprehension, visual attention, and auditory memory. There were no significant differences found in cognitive functioning between the study and control groups. The data, however, does not preclude eventual cognitive and educational deficiencies, nor aberrations in behavior, neurologic or motor functioning. Earlier and more prolonged exposure than that of the children in this study (mean maximal duration of ingestion of lead-based paint <3 years) might account for subtle cognitive and fine motor changes detected in children in an earlier study.

#### **Environmental Exposure to Lead: Analytical and Epidemiological Investigations Using the European Standardized Method for Blood Delta-Aminolevulinic Acid Dehydratase Activity Determination**

*A. Berlin, K.H. Schaller, H. Grimes, et al—Commission of the European Communities, Health and Safety Directorate, Luxembourg. INT ARCH OCCUP ENVIRON HEALTH 39(3):135-41, Aug 31, 1977.*

In 1973, personnel from 16 different European laboratories met and developed a common method for determining ALAD activity. This method is now termed the European Standardized Method. Precision within series of this method expressed as coefficients of variation ranged from 0.6 percent to 7.2 percent. Overall mean ALAD activity was  $23.6 \pm 3.8$  U/L giving a coefficient of variation of 16 percent.

Populations of male office workers exposed to environmental lead in their own locality were investigated with this method, and there proved to be quite a narrow range of ALAD activity levels for a given homogeneous population.

The European Standardized Method was proven as reproducible as methods used for other enzymes in clinical chemistry. In addition, relatively inexperienced personnel, employing equipment which is less elaborate than that for blood lead analysis, can handle large numbers of samples. Measurement of ALAD activity with

this method can thus be used for screening population exposure to environmental lead.

#### **Cerebellar Calcification: A Possible Marker of Lead Poisoning**

*J.I. Tonge, A.F. Burry, and J.R. Saal—State Health Laboratory, 63 George Street, Brisbane, Queensland 4000, Australia. PATHOLOGY 9(4):289-300, Oct 1977.*

An unusual form of calcification of the cerebellum has been observed in routine autopsies in Queensland over the past 25 years. In four separate surveys covering nearly 1500 subjects, 10 to 15 percent of cerebella examined showed evidence of folial calcification. The novel lesion, which has not been reported outside of Queensland, displays a different histological appearance and histochemistry from that seen commonly in the basal ganglia and elsewhere in the brain.

Investigations have demonstrated a significant correlation between cerebellar calcification and raised lead levels of bone. The lesion also occurs in most cases of lead nephropathy.

In acute lead poisoning, proteinaceous material accumulates in droplets in the cerebellum and globus pallidus and around blood vessels. This material may increase in density and undergo calcification, thus producing the lesion. Lead poisoning was formerly of epidemic proportions in Queensland. The cerebellar lesion may serve as a marker of previous lead poisoning.

#### **The Summer Disease: An Integrative Model of the Seasonality Aspects of Childhood Lead Poisoning**

*J.M. Hunter—Department of Community Medicine, Michigan State University, East Lansing, MI 48824. SOC SCI MED 11(14-16): 691-703, Nov 1977.*

Lead poisoning reaches an annual peak in both number and severity of cases during the summer months. Increased solar radiation in the summer elevates vitamin D levels which in turn cause increased absorption of lead from the gastrointestinal tract and increased absorption and recirculation of lead stored in body tissues. Experiments with animals seem to confirm this hypothesis, but have not substantiated the claim

that higher temperatures in the summer months play a role in increased lead poisoning.

Epidemiologic studies reveal seasonal variations in lead poisoning in both adult and child populations. Weather factors may play a role in such variations. Aerosol lead levels may increase in the summer due to increased automotive driving. Seasonal variations in wind patterns may also be significant. Increased play outdoors by children provides a supplemental source of lead ingestion, as well as exposure to aerosol lead particles. These factors, however, seem less important than increased solar radiation during the summer.

Lead is transferred across the placenta to the fetus. Since adult blood lead levels are highest during pregnancy and during the summer, maximum transfer occurs at these times.

An integrative model of seasonality can be developed; however further evidence is needed to establish quantitative parameters for public health planning and for clinical practice that will begin to take adequate account of seasonality. More accurate screening and treatment programs should then be possible.

**Clinical Study and Evolution of Various Biological Parameters (Pb, ALA-D, FEP) in 14 Cases After Ingestion of Lead-Containing Beverages (French)**

*M. Lob and M. Berode. SCHWEIZ MED WOCHENSCHR 107(46):1667-70, Nov 19, 1977.*

English summary: Clinical and biological evolution is reported in 14 individuals (adults, teenagers, children) who had ingested lead-contain-

ing beverages stored in glazed pottery. There are marked differences between adults and children regarding the half lives of lead in blood. Almost two years after the discovery of the risk, abnormal amounts of Pb, ALA-D and FEP remain in the absence of any other clinical disturbance. The hazard of glazed pottery is reemphasized.

**Serum Iron Concentration and Transferrin Saturation in the Diagnosis of Iron Deficiency in Children: Normal Developmental Changes**

*M.A. Koerper and P.R. Dallman—University of California, Department of Pediatrics 650 M, San Francisco, CA 94143. J PEDIATR 91(6):870-4, Dec 1977.*

Authors' abstract: A group of 359 healthy children and 49 adults were studied for the purpose of estimating the normal limits for serum iron concentration and transferrin saturation. The 144 children and 7 adults who had any other laboratory evidence of iron deficiency (abnormal values of serum ferritin, free erythrocyte protoporphyrin, hemoglobin concentration, or mean corpuscular volume) were excluded. In evaluating the 215 children and 42 adults who met the criteria to be considered normal we found that serum iron concentration and transferrin saturation were significantly lower in children between the ages of 0.5 and 12 years than in adults. We conclude that in children between the ages of 0.5 and 12 years, a transferrin saturation of 16 percent constitutes good evidence of iron deficiency only in conjunction with anemia and low mean corpuscular volume, [but a transferrin saturation of 7 percent indicates a high probability of iron deficiency.]

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## TREATMENT AND PREVENTION

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### **The Control and Prevention of Pediatric Lead Poisoning in East Orange, New Jersey**

*H.L. Margulis. J ENVIRON HEALTH 39(5): 362-5, Mar-Apr 1977.*

Author's abstract: The aging housing stock of East Orange, New Jersey, is heavily contaminated with lead-based house paints, although only 8 percent of the lead-screened child population, ages 1-6 have elevated blood-leads  $\geq 40$   $\mu\text{g}/100$  ml or blood-leads between 30-39  $\mu\text{g}/100$  ml and erythrocyte protoporphyrin levels  $\geq 60$   $\mu\text{g}/100$  ml. The city's success in controlling lead poisoning can be attributed to its property maintenance and housing code enforcement programs. [The code stipulates that any person who intends to sell, transfer or otherwise dispose of any type of housing must have the premises inspected to insure that they conform to the provisions of the property maintenance code. An inspection is also required before each change of occupancy of rental-dwelling units. The code requires that painted surfaces be tight and cleanable, and makes the owner or his agent responsible for regular inspection of their rental properties and for the abatement of code violations. As long as an active rental and resale property market exists in East Orange and the

housing stock remains in reasonably good condition, diligent enforcement of the present code should serve to prevent lead hazard.]

### **Reduction in Lead Levels Among Children in Newark**

*D. Gause, W. Chase, J. Foster, and D.B. Louria. J MED SOC NJ 74(11):958-60, Nov 1977.*

Authors' abstract: Annual figures on lead levels among five-year-old school children suggest that progress has been made in Newark's battle against pediatric lead poisoning. Over the three years sampled, there was a consistent increase in the proportion of children with lead levels below 30  $\mu\text{g}/\text{dl}$  for all ethnic groups. Furthermore, the figures for the school years 1974-1975 and 1975-1976 (which are more comparable because of changes in testing methods after the first year) show that the percentage of children with lead levels less than 30  $\mu\text{g}/\text{dl}$  rose from 49 percent to 71 percent among blacks, the largest ethnic group examined. [Despite this overall lowering of lead levels, 494 asymptomatic school children (10% of the 4,939 tested) were identified with lead levels above 39  $\mu\text{g}/\text{dl}$ .]

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