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Lead poisoning: a historical overview

The article in this issue of the *Journal* on occupational lead exposure by Fischbein et al[1] serves as a reminder that one of the oldest preventable diseases known to man is still with us. Outbreaks of lead poisoning have occurred since antiquity. The Greek poet-physician Nicander described the disease over 2,000 years ago. Roman food and drink, particularly reinforced wines, were heavily contaminated with lead. And, Sara C. Bisel, PHD, a classical archaeologist and physical anthropologist, reported in May 1983 at the annual meeting of the American Association for the Advancement of Science that chemical analysis of skeletons of Romans, killed by the eruption of Mount Vesuvius in 79 AD, indicated high lead content in at least eight individuals.

The Massachusetts Bay Colony forbade rum distillation in leaded stills in 1723 to prevent "dry gripes," an intestinal condition. In 1767 Sir George Baker blamed "the endemic colic of Devonshire" on the use of lead-lined troughs in the making of apple cider.[2] The dangers of occupational exposure to lead have been well documented for over a century, and since the early 1930s there has been increasing study and resulting concern about the problem of childhood lead poisoning associated with the ingestion of leaded paint. This led to the banning of leaded paint for interior use in the 1950s. Why then is lead poisoning, a truly preventable disease, still a cause for concern and the subject of so much study and worldwide controversy in the 1980s?

To understand the answer to this question, one must know the history of the fight against lead poisoning—one of the outstanding success stories in public health. Unfortunately, the failure to eradicate the disease also reveals the enormous frustrations and disappointments of workers in the field of public health. The intense battle against childhood lead poisoning illustrates the problem.

In the 1950s and 1960s, pediatricians, public health professionals, and other concerned citizens were appalled by the increasing number of inner city children living in substandard housing who were suffering from severe consequences of lead intoxication, including permanent brain damage and death. A national outcry resulted in the federal government appropriating millions of dollars to fight the "silent enemy." By the early 1970s, most of the major cities had begun federally funded childhood lead poisoning control programs. The conquest of childhood lead poisoning seemed within reach. Children were screened, treated, monitored, and removed from environments with high levels of lead. Data were collected and analyzed by the Centers for Disease Control, and a uniform reporting system was developed. As the number of children with extremely high blood lead levels dropped, as a result of aggressive control programs, reports began to come in from around the country of children with elevated lead levels not associated with exposure to lead paint.

Investigators searched for other sources of lead. Baby food, canned milk, and other canned foods were found to contain unacceptable concentrations of lead as a result of contamination from lead solder during the canning process. Bottles of fruit juices, particularly apple juice, were detected that had been contaminated by lead arsenate used as a pesticide spray on the growing fruit.

As each new source of lead was revealed, steps were taken to eliminate or mitigate the exposure. In 1970, in New York City, over 87,000 blood tests were performed on children; 2,700 results over 55 mg/dL were reported. By 1974, only 500 out of 125,000 tests were reported over 55 mg/dL. But now evidence was piling up that lower levels of blood lead were associated with subtle but serious neurobehavioral changes, and that many children were still being damaged. Allowable blood lead levels were lowered from 60 mg/dL to 40 mg/dL. Laws were proposed that further limited the concentration of lead in interior paint.

At this point, the Lead Industries Association, Inc (a nonprofit trade association whose member companies include most domestic producers and commercial consumers of lead) and some paint manufacturers fought the changes citing severe economic consequences to the industry and lack of demonstrable need. Testimony was presented to congressional subcommittees. The evidence supplied by the public health community was overwhelming and the laws were changed.

Research continued, and the association of blood lead levels to the amount of lead released into the atmosphere was probed. The records of 170,000 children screened by the New York City Lead Poisoning Control Program during 1970-1976 were reviewed, and venous blood lead levels and demographic data were analyzed.[3] The geometric mean of the blood lead levels showed a consistent cyclical variation superimposed on an overall decreasing trend with time for all ages and ethnic groups studied. Regression analysis indicated a significant statistical correlation between the geometric mean blood lead level and the ambient air lead level, after adjustments were made for age and ethnic group. As a result of this study and others, the Environmental Protection Agency (EPA) proposed a standard for the allowable concentration of lead in ambient air. Again the lead industry, including such giants as E I du Pont de Nemours & Co and the International Lead-Zinc Research Organization (ILZRO), opposed the standard; they were joined by the American Petroleum Association (an oil industry trade association), gasoline being the major source of air lead. Economics and the lack of demonstrable need were cited. Testimony was provided to the EPA and to Congress.

Again the public health community prevailed, and more stringent standards were set.

Continuing clinical research revealed that children were being damaged by levels once thought acceptable,[4] and the allowable blood levels were lowered from 40 mg/dL to 30 mg/dL. Studies showed a clear association between the amount of lead in gasoline sold in an area and the blood lead levels of children screened.[5] Data from the second National Health and Nutrition Examination Survey appeared to show a strong correlation between declining blood lead levels and the reduction in the amount of leaded gasoline sold. Further reductions in air lead were proposed, and the phase down and eventual banning of lead in gasoline was recommended. Again the lead industry, led by ILZRO, the Ethyl Corporation (the nation's leading producer of lead additives for gasoline) and others, fought back. Experts were flown in from around the world to testify before scientific committees of the EPA. Again the public health community rallied. William D. Ruckelshaus, administrator of the EPA, announced at a news conference on July 30, 1984, that the agency's intention was total elimination of leaded gasoline by 1995. Citing "overwhelming" evidence that lead in gasoline is a serious threat to health, Mr Ruckelshaus stated that the "social and economic benefits will be very substantial, and the costs will be minimal."

Over the years, the seemingly endless resources available to industry to fund research and to hire experts to challenge the scientific validity of the various studies that document the adverse health effects of lead have been a constant source of envy and frustration to the public health community, who must live within the contraints of very limited funding. It is also a severe disappointment to witness the defection of former colleagues, who were wooed by the availability of industry support for their research.

One of my professors of health administration, Dr Lowell E. Bellin, once told me that "Public health is incrementalism"; everything is accomplished one slow step at a time. And Dr John J. Hanlon writes that public health is applied social science.[6] I would add that it is also the integration of scientific fact with political and economic realism. And that is why, in the 1980s, lead poisoning, a truly preventable disease, is still with us, and why Dr Fischbein et al remind physicians to consider it in the differential diagnosis when treating individuals in certain occupational groups such as shipbuilders, construction crews, bridge maintenance workers, burners and welders, and others. Whereas decreasing blood lead levels in the general population, particularly in inner city children represent one of the outstanding success stories of public health, the struggle to reduce environmental and occupational exposure to lead points out the frustrations and disappointments with which the public health community must contend.

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NMR: a new perspective on medicine

For nearly four decades the nuclear magnetic resonance (NMR) phenomenon has provided physicists and chemists with an invaluable window to the structure, motion, and identity of molecules and their environments. Now NMR technology has advanced on medicine, providing high-resolution anatomical images that can identify pathologic changes, as well as profiles of metabolite concentrations that directly reflect the state of health of tissue in vivo.

The power of NMR technology lies in its versatility.[1] Since NMR occurs in any nucleus with an odd number of either protons or neutrons, many naturally occurring, non-radioactive isotopes such as hydrogen (^{1}H), carbon (^{13}C), phosphorus (^{31}P) and sodium (^{23}Na) are accessible to NMR examination. Such nuclei are slightly magnetic and therefore weakly polarize when placed in an external magnetic field. ^{1}H provides the greatest signal-to-noise ratio, constitutes two thirds of the nuclei in the body, and is therefore the most popular for imaging. ^{31}P and ^{13}C resonances are orders of magnitude less intense but nevertheless provide valuable metabolic information.

Three types of magnetic field are necessary for NMR imaging: a strong static magnetic field for polarizing the nuclei; a tuned radio frequency field for exciting the resonances; and x-, y-, and z- magnetic field gradients for spatially encoding the NMR signal.[1] The different nuclear resonances are selected by precisely matching the frequency of the exciting field to the desired nuclear resonance within the strong static field. For example, in a static magnetic