Lead Content of Human Hair (1871–1971)

Abstract. *Samples of antique and contemporary human hair were analyzed for lead by atomic absorption spectroscopy. Antique hair contained a significantly greater amount of lead than did contemporary hair.*

The National Academy of Sciences has released a report entitled "Airborne lead in perspective" (*1*). This report details the present state of knowledge concerning atmospheric lead concentrations and their effects on plant, animal, and human populations. These concentrations have risen steadily since 1940 (*2*), and their effect on the population in the United States has been subject to much debate (*3, 4*). However, quantitative information on the effect of lead on the population prior to the introduction of tetraethyl lead into gasoline in 1923 is not available (*3*). In the present study we compared the lead content of human hair removed from persons between 1871 and 1923 with that of hair obtained from rural and urban populations in 1971. The lead content per unit weight of hair was significantly higher in the antique population (1871–1923) than in present day populations (Table 1). These results indicate that the lead content of human hair has markedly decreased in the last 50 years in spite of a general increase in atmospheric lead concentrations.

Lead enters the human body primarily through the alimentary and respiratory tracts. Following absorption, lead is carried in the blood and is deposited in many tissues, including hair. Hair provides an index of personal exposure to lead in the environment and concentrates more lead per unit weight than any other tissue or body fluid (*5*). This constantly growing tissue preserves a record of lead exposure and has the advantage that it is readily obtained, stored, and analyzed. During growth, the emerging hair accumulates and retains a variety of heavy metals, which are firmly bound because of their great tendency to complex with the abundant sulfhydryl groups in the follicular proteins. Lead is normally present in the hair of healthy subjects, but its concentration varies widely, depending on diet and environment. Although conflicting reports have been presented concerning the lead content of hair as an index of body burden (*6, 7*), Kopito *et al.* (*5*) have shown good correlations between the amounts of lead in hair and the radiographic findings of increased lead content in bones. The presence of lead in hair reflects the prior presence of lead in the blood regardless of its ultimate destination. For these reasons and because hair samples from both antique and contemporary populations were available, human hair was used in this study.

Experiments were designed to compare the lead content of human hair in urban populations from five locations in or near Philadelphia, Pennsylvania; in a rural population from the western Upper Peninsula of Michigan; in a population of biology teachers representing 14 states at a summer institute of the National Science Foundation; and in an antique population dated between 1871 and 1923, representing 11 states. Contemporary hair samples were obtained through barber shops and antique samples through advertisement (*8*). The age, sex, and hair color of the donor were recorded for each sample. The contemporary and antique samples were dichotomized according to two age groups; persons younger than 16 were considered children and those older than 16 adults. No significant differences due to sex or hair color were found either within or between groups and, therefore, samples were grouped without regard to these parameters.

The methods of analysis were basically those of Harrison *et al.* (*9*). Samples were cut into segments less than 1 cm in length and treated to remove surface contamination by washing in 500-ml polyethylene bottles with 150 ml of a 1 percent nonionic detergent solution (*10*). The bottles were agitated on a mechanical shaker for 30 minutes at room temperature. On completion of the washing cycle, the samples were transferred to a polyethylene filter crucible and rinsed with a total of 1 liter of deionized water to remove the detergent. The samples were dried to constant weight at 110°C, weighed to the nearest 0.1 mg in erlenmeyer flasks, and digested with 5 ml of nitric acid (*11*) and 1 ml of perchloric acid (*12*). Following digestion, the perchlorate anion (which interfered with atomic absorption analyses) was driven off by evaporation to dryness, and the samples were dissolved in 5 ml of deionized water. Lead analyses were performed on these samples by using a Beckman atomic absorption spectrophotometer. All samples were run in duplicate or triplicate along with a reagent blank and a standard curve. Lead shot (Mallinckrodt, > 99 percent purity) was used as the primary standard. Values are reported as micrograms of lead per gram of hair (dry weight).

The data in Table 1 indicate that the lead content of human hair was significantly higher in both children and adults living in the years 1871 to 1923 than in present-day populations. Similar findings based on bone analysis have been reported (*13*). McCord (*14*), in a series of reports on lead and lead poisoning in early Americans, points out that widespread exposure hazards existed into the early part of this century due to collection of water from lead roofing, storage of water or other

Table 1. Lead content of human hair from antique (1871–1923) and contemporary (1971) populations. Persons younger than 16 are classified as children, and those over 16 as adults. The results are expressed as mean values plus or minus standard errors. The numbers in parentheses indicate the number of samples in each group.

Age group	Lead in hair (μg/g, dry weight)	
	Antique	Contemporary
Children	164.24 ± 20.7 (36)	16.23 ± 0.97 (119)†
Adult	93.36 ± 16.3 (20)*	6.55 ± 1.17 (28)*†

* Significant from children at $P < .01$. † Significant from antique at $P < .01$ (by using a t-test).

Table 2. Lead content of children's hair from several populations within the metropolitan Philadelphia area compared with a population from Michigan's Upper Peninsula. The results are expressed as mean values plus or minus standard errors. The numbers in parentheses are the number of children in each group.

Sample population	Lead content (μg/g, dry weight)
Philadelphia (Chestnut Hill)	16.49 ± 2.9 (16)
Philadelphia (Kensington)	19.44 ± 2.8 (16)
Philadelphia (Germantown)	16.74 ± 2.7 (16)
Philadelphia (Lawndale)	13.96 ± 2.2 (16)
Newtown, Pennsylvania	11.08 ± 2.2 (16)
Michigan (western Upper Peninsula)	17.63 ± 1.7 (39)

fluids in leaded jugs, and the use of improperly glazed earthenware and leaded paints and cosmetics. The high concentrations found in our antique population most likely reflect a greater ingestion of lead than would be expected for contemporary populations, with the exception perhaps of ghetto children, persons drinking illicit alcohol, or special industrial populations whose exposure to potential sources of contamination is unusually high. Thus, the lower lead content in human hair in our contemporary population is probably a result of greater precautions in the use of lead in spite of a general increase in atmospheric concentrations (*2*).

No significant differences in the lead content of hair between populations of children from Philadelphia and a group from Michigan's western Upper Peninsula were found (Table 2). Hammer *et al.* (*6*) have shown a good correlation between the lead content of children's hair and the lead exposure ranking in five selected cities. Their values for cities with a low lead exposure ranking are similar to our values for both children from Philadelphia and children from the western Upper Peninsula. Goldsmith (*1*, p. 62) reported that no significant correlation could be established between atmospheric lead and blood lead concentrations when the atmospheric lead concentrations were below 2 $\mu g/m^3$. The atmospheric concentrations in Philadelphia and Michigan's Upper Peninsula are probably below this level; this may account for the fact that differences between these populations could not be demonstrated.

The significantly lower lead content observed in adult hair compared with that of children (Table 1) is consistent with other reports (*15*) and reflects a generally higher metabolic level in children and the fact that absorption decreases with age (*3*).

In this study we do not intend to minimize the effect of environmental lead on man's health. However, we have demonstrated a decrease in the lead content of human hair between 1871–1923 and 1971 in spite of an increase in atmospheric lead.

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16. We thank the Philadelphia *Inquirer*, *Hearst's Outbursts*, *The Antique Trader*, and *Antiques Inc.* (Shaker Heights, Ohio) for their help in obtaining antique hair samples.

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Expression of Lactate and Malate Dehydrogenases in Tumors Induced by SV40 and 7,12-Dimethylbenz(a)anthracene

Abstract. *Isozyme patterns of lactate and malate dehydrogenases were studied in tumors induced by SV40 and 7,12-dimethylbenz(a)anthracene and in established cultures of cells from these tumors. The expression of B polypeptide subunits of lactate dehydrogenase is suppressed similarly by both agents. This may be due to inactivation of the gene at the locus determining the B polypeptide subunit. Malate dehydrogenase isozyme patterns are not changed significantly by the virus or the carcinogen.*

Neoplastic transformation in vitro and in vivo by oncogenic viruses (*1*) and carcinogenic hydrocarbons (*2*, *3*) is well documented. We investigated the expression of lactate dehydrogenase (LDH) and malate dehydrogenase (MDH) in tumors induced by SV40 and by 7,12-dimethylbenz(*a*)anthracene (DMBA). The tumor cells grown in tissue culture were also studied.

Extracts from normal muscle tissues (adjacent to tumors) in hamsters show five distinct bands of LDH after starch gel electrophoresis (Fig. 1). Each of these proteins is a tetramer composed of four polypeptide units (*4*), and the polypeptide subunits can be of two different kinds, A and B (sometimes called M and H). The two distinct polypeptide subunits are determined by separate gene loci (*5*).

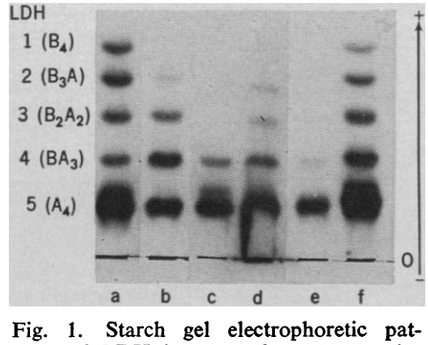

Fig. 1. Starch gel electrophoretic patterns of LDH isozymes from tumors induced by SV40 and DMBA and from corresponding transformed cells in culture (*O*, origin). Samples are (a) control muscle tissue, (b) DMBA-induced tumor, (c) DMBA-transformed cells in culture (passage 10), (d) SV40-induced tumor, (e) SV40-transformed cells in culture, and (f) control muscle tissue.

Electrophoresis was performed on homogenates of tumor tissues, control muscle tissues, and transformed cells; tissue was either freshly prepared or had been stored at −20°C. The tissues were washed three times in 0.9 percent saline containing $6.6 \times 10^{-4} M$ ethylenediaminetetraacetic acid (EDTA) and twice in deionized water to remove erythrocytes. Homogenates were prepared by grinding the tissues in a glass homogenizer with deionized water (2 cm^3 of water per gram of tissue). The crude extract was centrifuged for 30 minutes at 11,000 rev/min. Samples of supernatant, either full strength or diluted with deionized water, were used for electrophoresis.

The virus-induced tumor studied, HCO_2clI, is a clone derived from H-50 IS cells, which had been derived from a tumor induced by SV40 in a newborn hamster (*6*). The DMBA cell lines were derived from a tumor induced by DMBA. Tumors were induced by injecting 2.3 mg of DMBA in 0.1 ml of acetone into each adult hamster, as described by Lausch and Rapp (*7*). We