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Lead Content in Human Scalp Hair of Rural and Urban Residents in Taiwan

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In the last three decades, vehicular traffic has increased drastically in Taiwan, from 50 thousand registered motor vehicles in 1967 to over 5 million at present. Although the lead content of leaded gasoline produced in Taiwan was reduced from 0.56 g/L to 0.12 g/L between 1982 and 1988, half of these vehicles still use leaded gasoline. It is one of the major sources of lead contamination in the ambient air and dust in the city. The suitability of hair analysis as a means of screening for heavy metal exposure and heavy-metal poisoning is well documented (Klevay, 1973; Maugh, 1980). Numerous investigations worldwide have shown that hair lead concentrations are strongly correlated with the lead concentrations of other organs in the body (Kopito et al., 1967; Chattopadhyay et al., 1978; Verheul, 1985). Hair presents an advantage from the sampling point of view because it is easily obtained, stored and analyzed. It also concentrates more lead per unit weight than any other tissue or body fluid. It has been estimated that for healthy persons, the lead concentration in hair may be 2-5 times higher than that in bone, 10-50 times than that of blood and from 100-500 times higher than in urine (Valkovic, 1977; Hansen, 1981). The determination of trace elements in human scalp hair has become an accepted adjuvant to the more traditional blood and urine analyses for identifying systemic heavy metal intoxication. In this study, the concentrations of lead were measured in hair from an urban and a rural population in Taiwan. The levels and distributions of lead between rural and urban residents were compared.

MATERIALS AND METHODS

The number of samples and sampling location for each of the study groups and the distribution of samples according to sex for the rural and urban groups are shown in Table 1. Hair samples were collected from 90 persons aged between 5 and 63 years: 45 subjects from the urban area of a central Taipei residential area (24 males and 21 females), and 45 subjects from two villages (Shangshi and Mioalli) in the rural area of Taipei county about 100 km south of Taipei (26 males and 19 females).

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The rural subjects were from areas where the residents were engaged in agriculture-related occupations. Samples were obtained from a normal haircut by hairdressers. Donors were asked to supply information on their age, sex, and area in which they lived. Hair which had been dyed or bleached was not collected. Immediately after being cut, the hair was stored in plastic bags and attached to the questionnaire.

Table 1. Distribution of hair samples according to two groups, sex and average age.

	Males	Females	Total	Average age
Urban	24	21	45	25.2
Rural	26	19	45	25.8

Of major concern in the evaluation of hair lead level is sample contamination. An elaborate cleaning procedure was necessary to rule out contribution of incidental lead occurring external to the body. The hair was first washed with acetone, then three times with water, and then once more with acetone. Sufficient amounts of these solvents were added to cover the samples entirely. The samples were agitated for 10 minutes at room temperature after the addition of each new solvent. After each wash, the liquid was decanted and fresh solvent was added. Each sample was air-dried, weighed and heat-sealed with polyethylene envelopes. The loss of weight due to removal of surface dirt and particulate matter during this multi-step process is about 25 % of the initial weight (Clarke and Wilson, 1974). In general, it is convenient to prepare a sample large enough to permit at least a duplicate run to be made.

Compared to other tissues, hair is easy to achieve complete digestion due to its low lipid content. Dissolution of hair is necessary to measure its trace element content. A 0.5-1 g portion of the dried sample along with 8 ml concentrated HNO_3 and 2 ml $HClO_4$ were placed in a Kjeldahl flask overnight. The samples were then wet ashed slowly until a transparent residue remained in the bottom of the flask. The solution was carefully maintained below the boiling point to permit evaporation without loss of metal due to aerosol formation. The solution was then cooled, quantitatively transferred to a 10 ml volumetric flask, and filled to volume with double deionized distilled water.

To avoid contamination, all glassware was soaked in 42 % HNO_3 for 16 hours and then rinsed with double deionized distilled water. Analytical standards for lead were prepared by volumetric dilution from a lead standard solution (Wako Pure Chemical Industries, Japan), which had a nominal concentration of 1000 mg/L. A check was made for impurities in the acids and possible contamination from Kjeldahl flasks and propylene test tubes. Blanks were tested on several different days by introducing only the nitric acid and perchloric acid used during the mineralization procedure. A Hitachi Atomic Absorption Spectrophotometer 180-30 was used, and a maximum sensitivity was adjusted at the wavelength of 283.1 nm for lead.

RESULTS AND DISCUSSION

This study was designed to determine lead content in hair of residents from rural and urban areas of Taiwan. Table 2 lists the lead content in hair of the two groups. The lead values in hair of the rural residents were in the range of 1.34-25.94 µg/g hair with an arithmetic mean of 6.11 µg/g hair. The lead values in hair of the urban residents were in the range of 1.35-25.20 µg/g hair with an arithmetic mean of 6.20 µg/g hair. No significant difference in lead content between the two groups was observed. The frequency distribution of hair lead content in each group is shown in Figure 1. The profiles of the frequency distribution of the groups were almost similar. Figure 2 indicates that lead content in hair of urban residents decreased with age. No significant difference in lead content between the two residents except for the group of 30-50 years old was observed.

Table 2. Hair lead content in urban and rural residents.

	Mean content (mean ± SD) µg/g	Range (min. and max.) µg/g
Urban (N=45)	6.20 ± 4.80	1.34 - 25.20
Rural (N=45)	6.11 ± 4.34	1.30 - 25.94

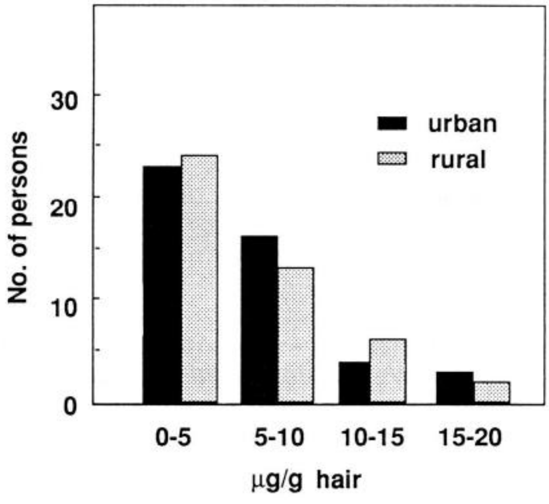

Figure 1. Frequency distribution of urban and rural residents

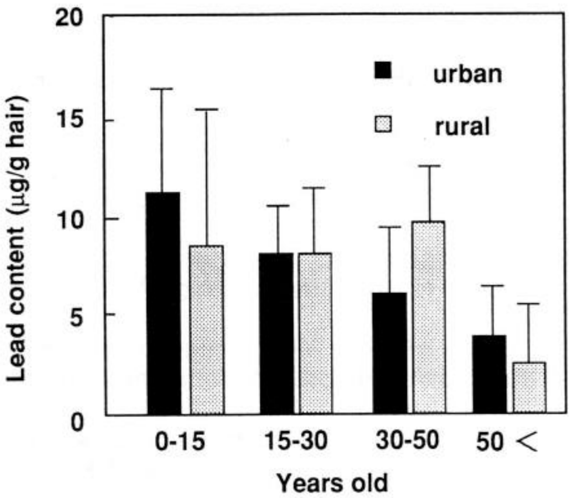

Figure 2. Variation of hair lead content with age. The values are mean ± SD.

Our results show that the hair lead content of the 90 Taiwanese subjects is, at present, comparable to and even lower than the ranges reported worldwide for normal, non-occupationally exposed populations (Hansen, 1981; Suzuki et al., 1984; Takagi et al., 1986). They are also within the range recommended by Petering et al. (1973) for normal non-toxic exposure.

Respiratory exposure to lead is related to the body burden of lead. Due to the sharp increase of cars in Taiwan in the past decade, the concern for lead contamination in the environment has grown. The use of unleaded gasoline is now required in newly manufactured automobiles since 1991. Regulation of the fuel lead content may largely reduce the Taiwanese population's exposure to lead. The following are results of similar investigations in other geographical area. In Spain, hair lead content was determined in 478 school children living in an industrial and agricultural area of Tarragona Province (Schumacher et al., 1991). Although the average hair lead content was slightly higher in the industrial area than in the agricultural area, the difference was not statistically significant. On the other hand, data for other countries e.g., the United States (Folio et al., 1982), New Zealand (Creason et al., 1983), Holland (Wibowo et al., 1986), Russia (Revich, 1994) and Saudi Arabia (Ahmed et al., 1989) showed that the hair lead content of residents in urban areas of massive lead contamination was higher than those of rural, uncontaminated areas.

No significant difference in hair lead content was observed between the rural and urban Taiwanese residents. It appears that at present, hair lead levels in Taiwan are below the toxic level and are within the reported normal range.

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