# LEAD IN FINGER NAILS AND SCALP HAIR OF ADULT MALES IN KENYA

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## Abstract:

Lead concentration was determined in finger nails and scalp hair of exposed and unexposed males by atomic absorption spectrometry (AAS). The mean levels of Pb in the finger nails ranged from 50-480 µg/g, and 50-240 µg/g for exposed and unexposed males respectively. The mean levels of Pb in the scalp hair ranged from 30-410 µg/g, and 30-200 µg/g for exposed and unexposed males respectively. The study established that the mean Pb levels in both the finger nails and the scalp hair samples increased with increase in age. The mean Pb levels for all the age categories studied had significant differences at $\alpha=0.05$, $p<0.05$ (One-way Anova). Comparing the mean lead concentration in scalp hair with finger nails a significant difference was indicated in the two tissues ($P<0.05$). Even though the Pb levels were higher in the finger nails as compared to the scalp hair in all the male subjects, it is reasonable to say that the two tissues are recording filaments that can be used to know the extent of heavy metal pollution in the environment as well as the levels of essential trace elements.

**Key words:** Males, Lead, Fingernails, Scalp hair, AAS, Determination, Kenya

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**Introduction:**

Nail as a bio-indicator has received a great deal of attention in the literature (Hayashi et al., 1993; Ju, 2002; Sukumar and Subramanian, 2003; Mehra and Juneja, 2005; Sukumar, 2006; Vinceti et al., 2007; Were et al., 2008). Concentration of toxic metals in nail tissues have been reported to be in order of magnitude higher than those of body fluids and other accessible tissues (Rodushkin and Alexelsson, 2000; Sukumar and Subramanian, 2003). Nail sampling has been proposed to be cheap, non-invasive and well tolerated method for accessing accumulated toxic and essential metals in the tissues (Takagi et al., 1988). Hair is an excellent indicator of past changes in metabolism and environmental exposure to metals (Ashraf et al., 1995; Ajayi et al., 2001). The growth rate of human hair is approximately 1 cm per month (Wolfsperger et al., 1994). Hair analysis for trace elements is influenced by a number of factors including geographical location (Kaspereck et al., 1982; Ajayi et al., 2001; Rosborg et al., 2003) age and sex (Ashraf et al., 1995; Bertazzo et al., 1996) and treatment with various chemicals and shampoos are also variables to consider (Rosborg et al., 2003). Nail and hair tissues have been suggested as suitable biomarkers in developing countries due to their easy sample collection, storage and preparation for analysis (Barbosa et al. 2005; Were et al., 2008).

Lead is a non-essential element with no known biological function in the body. It has raised concern among heavy metals, due to relatively high toxicity and elevated quantity in the environment as a result of their widespread use (Cambra et al., 1999). Further, Pb does not have any known biological use but is widely used in the industries (Mielke et al., 1999; Gaw et al., 2006). It is well documented that human beings may be exposed to lead through contamination of food, water, house, leaded dust, soil and through industrial activities such as metal recycling, battery industry and flaking paints (Park and Palk, 2002; Nabulo et al., 2006). Nabulo et al. (2006) found that when Pb is released into the air, it stays there for ten days and most of it in the soil comes from particles falling from the air. Risk factors have been reported to exacerbate the absorption of Pb into the bodies of human beings (Albert and Badillo, 1991; ATSDR, 2000; Were et al., 2008). There are many risks factors which may increase the exposure of human males to Pb. The social demographic risk factors include; age, race/ethnicity, income, education, housing vintage, poverty status among others (Industrias, 1996; Sukumar and Subramanian, 2003). The environmental risk factors includes; living near heavy traffic road, eating exposed foods, source

of water, use of glazed ceramics, living near a Pb based industry, smoking, duration of stay near an industry, influence of early child hood diseases, among other factors (Kyle, 1992; O'Neill, 1993; Chakrabati et al., 1996; Owago, 1999; Oyaro, 2000; Park and Palk, 2002; Were et al., 2008; Mogwasi, 2009). The occupational risk factors include; working in industries dealing with lead based products for example, paints, car batteries and radiators, drivers/conductors, petrol station attendants, traffic policemen, artisans, among others factors (Oyaro, 2000; Park and Palk, 2002; Were et al., 2008; Mogwasi, 2009). These may greatly contribute to elevated Pb levels in the body. Lead is of a particular concern as there is increasing evidence that relatively low levels of exposure affects mental development of the child whose toxicity increases even in adulthood and may cause permanent mental and behavior disorders (Lanphear et al., 2005). In general Pb poisoning results in adverse health effects associated with hematological, gastrointestinal; and neurological system. Lead also affects the CNS and causes neurological symptoms that have been reported with BPb of 40-60 µg/dL (Cambra et al., 1999). Slowed nerve condition in peripheral nerve of adult has also been observed at BPd of 30-40 µg/dL (Carnifield et al., 2003). Studies have found that first exposure to neurotoxicants such as Pb might lead to decreased reserve capacity of the brain, detrimental effects on neuropsychological factor which may become apparent in old age (Tang et al., 2003). Toxicity of Pb is also manifested in male reproductive system by deposition of lead in testes, epididymis, vas deferens, seminal vesicle and seminal ejaculate (Roy et al., 1986). Deficiencies of essential elements exacerbates Pb uptake in the body (Nowak and Chmielnicka, 2000). It is important to note that human males are not exempted from diseases and ailments that are brought about by essential trace element deficiencies, it is therefore imperative that human males are advised accordingly on proper eating habits. This will go a long way in reducing the effects of Pb pollution besides reducing its absorption in the body.

**Area description:**

Nairobi, cover an area of 697 $km^2$ with a population of over 3.1 million (CBS, 2010). Nationally it is established to have the greatest concentrations of industrial and vehicular air pollution sources (UNEP, 2006). It is reputed to be the fastest growing city of the world and lacks air quality management system (Mulaku and Kariuki, 2001). Indeed among the developing countries cities that were sampled for the study on air quality management capabilities, Nairobi was rated

the worst (UNEP/WHO, 1996). The city is now regarded as a "hot zone" with highest concentration of pollutants which has been influenced by increasing industries, population, construction, heavy traffic density and deforestation of city fringes (Mulaku and Kariuki, 2001). The CBS (2010) reported that Mathira is situated in central Kenya with a population of 152,000 and covers an area of 434 $Km^2$. It is a rural setting with few vehicles and industries. The study sites included schools and homes situated in this agricultural region, in which coffee, tea and horticultural crops are predominant. These crops requires substantial amount of fertilizers and pesticides for their production. These chemicals have heavy metals in-put. Therefore it was the aim of this study to determine levels of lead in the fingernails and scalp hair samples of males over the age of 18 years in different environmental settings to find out whether they accumulate metals differently.

**Experimental:**

Participation of all the subjects in this study was voluntary and relevant permits were obtained prior to the study. Confidentiality of the data collected and subsequent findings were assured by using only code numbers for each participant. Participants were free to terminate participation at their convenience. Any subject who would later like to know the levels of elements in his finger nails and scalp hair samples would do so. Field visits and sampling began in June 2010 and ended in September 2010. Samples were obtained from Nairobi and Mathira.

**Equipment and reagents:**

Atomic Absorption Spectrophotometer (AAS-Spectr AA-10, Varian- Techron, Austria) was used. Water used throughout the analytical procedures was deionised and distilled. Weighing balance used was Mettler Toledo AG-240. Digester block was 2080/DA, No 935, Volt 220-w Germany,- LIEBISCH BIELEFELD 14. Reagents used in the analysis were of high quality analytical grade. Liquid soap-an Izal product, nitric acid AR, acetone, 4-methyl pentan-2-one and perchloric acid were supplied by Hopkin and Williams, England. The plastic bottles were cleaned with non-ionic liquid soap rinsed with distilled water. They were then soaked overnight in 1:1 nitric acid and rinsed thoroughly with deionised and distilled water. All the glasswares used in this study were decontaminated by soaking them overnight in 5 % $HNO_3$ and rinsed thoroughly in deionised and distilled water. They were oven dried at 105 $^oC$ and stored safely. The metal standards from the stock solution (1000 µg/mL) were freshly prepared daily by serial dilution and checked for constancy of the results before taking the readings.

**Sampling:**

Two hundred (n=200) males over the age of 18 years were randomly recruited. Consent was sought from parents/guardians in case the subject was still under their care. The informed and consented subjects (n=200) filled a self-administered questionnaire. This took into account the previous findings and the WHO (1996) recommendations. The questionnaire elicited information on demographic characteristics, health conditions, socio-economic background, environmental risk exposure factors and diet habits of the subjects. The diet habits considered factors such as consuming processed food, canned with high fat content and marginal proteins. The environmental risk factors included; working in industries, petrol stations, drivers and conductors, those people who spend most of their time traveling, living near the road, living in a house painted with leaded paint or use of glazed ceramics utensils frequently, consuming exposed food from open air market or streets and taking water from leaded piping or borehole water frequently.

Purposive sampling strategy was used to select males in both urban and rural settings. The major criterion for selection of males in urban areas was influenced by the intensity of pollution, one hundred and twenty (n=120) subjects were recruited under this category. In Mathira rural, the criterion for selection was that it is in the interior far from urban influence. Therefore, eighty (n=80) subjects were recruited under this category. Each recruited subject gave his paired sample of finger nails and scalp hair.

In view of high prevalence of bacterial and fungi infections, each subject was given a labelled stainless steel nail clippers and a towel. All the fingernails and scalp hair samples of the subjects were cleaned using surgical spirit followed by non-ionic detergent. They were rinsed with water then dried with a clean towel. In order to minimize secondary contamination with metallic elements the stainless steel nail clippers were washed with analytical reagent grade HCl, diluted at 1:10 then rinsed with distilled water. Twenty eight (n=28) subjects were excluded from this study as either they dropped from the study or were unable to get sufficient samples for analysis. Fingernails and scalp hair were clipped from the same subject once in two weeks for a period of three months. The samples (n=344) were kept in labeled plastic bottles under lock and key until they were analysed.

**Laboratory procedure and quality assurance:**

Analysis of nail and hair samples was carried out using standard methods as reported by Mehra and Juneja (2005) and Sukumar and Subramanian (2003).

**Sample pre-treatment:**

Great care was taken to avoid external contamination of samples during analytical procedure. The fingernail and scalp hair samples were separately soaked in non-ionic liquid soap in a glass beaker for two hours and washed free from metallic debris following a standardized washing procedure (Mehra and Juneja, 2005; Sukumar and Subramanian, 2003). They were subsequently soaked in acetone for one hour and rinsed five times in deionised and distilled water. The samples were kept in vial tubes, and oven dried at 60 $^{o}$C to a constant weight. The polished fingernail and scalp hair samples were separately placed into beakers to which 10 mL of 4-methyl pentan-2-one was added and left for 45 min. They were then rinsed three times using deionised and distilled water before oven drying. The samples were weighed in triplicates and kept in the desiccators.

**Acid digestion and AAS analysis:**

The dry 1.0000 g samples were quantitatively transferred into digesting tubes. A 6 ml aliquot of concentrated nitric acid was added and heating done until brown fumes were observed, the solution was cooled to room temperature after which 1 ml of concentrated perchloric acid was added. The digesting tubes were then covered with aluminum foil and placed on digester block in a fume chamber and subsequently heated at 180 °C (Mehra and Juneja, 2005); use of open digestion is discouraged due to air borne particles, and loss of volatile elements and production of hazardous vapour (Samatha et al., 2004). The samples were then allowed to digest slowly for about one hour until all the samples (nails or hair) dissolved to form a clear solution. The digested sample solution was diluted with 1 ml aliquot of 0.1 N $HNO_3$ and then quantitatively transferred into a 100 ml volumetric flask, and volume adjusted to the mark with distilled water. They were then put in plastic bottles, labeled and stored under lock and key awaiting AAS analysis.

Analysis of nail and hair samples was carried out using standard methods as reported by Mehra and Juneja (2005) and Sukumar and Subramanian (2003). Concentration of Pb was assayed by use of AAS in triplicates with acetylene flame (the accuracy of the AAS was checked by triplication of the samples). A series of standards were prepared by serial dilution of the stock solutions containing 1000 µg/l of the metal and were used for instrumental calibration. For quality control, standards and blank samples were analyzed for every ten samples analyzed. The main instrumental parameter for example band width, lamp current, height of the flame and wavelength

for AAS were optimized for Pb. Detection limit of the instrument used for the analysis of Pb was 0.020. Adequate quality control was ensured by inter-laboratory comparisons of representative samples carried out at Kenyatta University Research Laboratory and Mines and Geology Analytical Research Department, Nairobi. The validity of method was further ascertained by linearity of calibration curves and regression equations.

**Data analysis:**

Statistical calculations were done using statistical SPSS program (Statistical Package for Social Sciences Version 17).

**Results and discussion**

The age distribution of the respondents from rural and urban areas is presented in Figure 1.

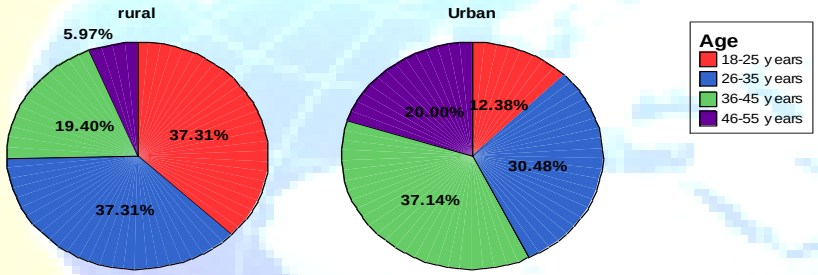


**Figure 1: Age distribution of the respondents from rural and urban areas**

Most of the respondents from the rural area were in the age category 26-35 yrs and 18-25 yrs. Most of them are actively in horticultural farming or are students. In urban areas majority of the respondents are in the age category 36-45 yrs and very few in the age category of 18-25 yrs. The Pb levels in the finger nails and scalp hair of males from rural and urban areas are summarized in Table 1.

**Table 1: Mean Pb levels (µg/g) in scalp hair and finger nails of urban and rural subjects**

| | Finger nail samples | | Scalp hair samples | | |
|---|---|---|---|---|---|
| Element | rural | urban | rural | urban | P-value |
| Pb | $126.25\pm4.05^{b}$ | $275.92\pm11.13^{d}$ | $79.36\pm3.85^{a}$ | $176.39\pm8.11^{c}$ | <0.001 |

Mean levels followed by different small letters within the same row are significantly different $\alpha=0.05$, $p<0.05$(One-way Anova)

From Table 1, the mean levels of Pb was highest in the nails from urban subjects (275.92±11.13 µg/g) and lowest in the hair of the rural samples (79.36±3.85 µg/g) the mean levels of Pb in the finger nails and scalp hair samples from rural and urban areas all were significantly different. The mean levels of Pb were higher in the urban respondents than in the rural respondents in both finger nails and scalp hair samples the means were significantly different. The results indicate that the level of lead is higher in subjects from the urban areas than from the rural areas. This could be as a result of the increased environmental pollution due to mushrooming of many industries dealing with heavy metals which could be released to the environment and find their way into the bodies of human beings, vehicular density also could be a contributory factor to this high level of lead since most vehicles could still be using leaded gasoline which when emitted into the atmosphere can then be inhaled into the body. Oyaro (2000) noted that the concentration of Pb in large cities where there was heavy traffic using leaded gasoline and near highways was so high to cause toxic reactions in some individuals. Mbaria (2007) reported that Kenya proposed to ban the use of leaded fuels in vehicles by September 2006, though a lot of leaded fuel was in use by 2007. There could also have Pb aerosol deposition on vegetables, fruits among other food substances which could have been grown along the roads or are sold in open places where there is heavy traffic. Besides this there is occupational exposure among other risk factors. Although the subjects in the rural area had lower levels of Pb than their urban counter parts, the levels were dangerous for human health. The elevated levels of Pb in the rural areas could be as a result of the fertilizers and a wide range of pesticides used in this highly agricultural area since most of the subjects were farmers and students.

The mean Pb levels were generally higher than those reported by Wilhelm and Hafner (1993); Rodushkin and Alexelsson (2000) Mehra and Juneja, 2005; Were et al., 2008; and others in finger nails and scalp hair. The levels were higher than those reported in blood (Owago, 1999; Mogwasi, 2009). However, the mean levels were generally lower than those reported by Ayodele and Bayero (2009) 0.384±0.34 mg/g and 0.464±0.364 mg/g in hair and finger nails respectively for exposed subjects to environmental pollution. The relationship between the levels of Pb in the finger nails and scalp hair with age was also determined and the results are summarized in Table 2

**Table 2: Relationship between age and mean Pb levels (µg/g) in the rural and urban setting**

| | Finger nail samples | | Scalp hair samples | |
|---|---|---|---|---|
| Age | Rural (N=67) | Urban (N=105) | Rural (N=67) | Urban (N=105) |
| 18-25 years | 100.14±6.35[a] | 154.46±24.37[a] | 57.44±3.94[a] | 115.38±20.84[a] |
| 26-35 years | 136.98±3.49[b] | 233.94±19.37[b] | 81.32±4.01[b] | 157.16±13.31[ab] |
| 36-45 years | 142.23±4.13[b] | 318.28±15.03[c] | 103.31±6.80[c] | 193.03±13.02[b] |
| 46-55 years | 170.50±24.64[c] | 336.43±19.37[c] | 126.25±30.10[d] | 212.57±17.19[b] |

Mean levels followed by different small letters within the same column are significantly different $\alpha=0.05$, $p<0.05$(One-way Anova)

The results established that the mean Pb levels in the finger nail were higher than the Pb levels in the scalp hair; there was a significant difference in these levels in all the age categories studied irrespective of whether the subject came from urban or rural area. The results are in agreement with findings of other researchers who reported varying concentrations of Pb in hair and nail samples (Ayodele and Bayero, 2009). Similarly Pb levels increased with increase in the age of the subjects, perhaps due to increased period of exposure to this toxic heavy metal. Our study results were in agreement with other studies done elsewhere (Sukumar and Subramanian, 2003; Mehra and Juneja, 2005; Nnorom et al., 2005) and supported by those of Moses and Prabakaran (2011) who reported higher Pb levels in older subjects. However, the results were inconsistent with those of others (Caroli et al., 1992; Sanna et al., 2003; Were et al., 2008) who reported that younger subjects had higher metal levels in hair than older ones.

**Conclusions:**

The levels of Pb were high in the two tissues irrespective of whether the subject was from rural or urban area and considering that the finger nails and scalp hair are points of excretion it therefore means that the levels are equally high in the body. Therefore scalp hair or finger nails are recording filaments that can reflect the extent of environmental pollution.

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