Influence of Dietary Habits on Essential Elements and Lead Levels in Finger Nails and Scalp Hair of Adult Males in Kenya

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***Abstract*: The influence of dietary habits on levels of Pb and essential elements Zn, Fe, Ca and Mg was evaluated on finger nails and scalp hair of exposed and unexposed males in Kenya using AAS. In recent years studies have shown that there are increased human health disorders due to negligible concentration of essential elements in the body. This could be due to the poor eating habits especially exhibited by the male population who in addition work in areas that expose them to lead pollution. Lead levels are known to influence essential element levels. The factors that were found to have significant influence on Pb and essential element levels in hair and nails included: use of glazed ceramics, consumption of canned and highly processed foods, consumption of exposed foods and sources of water among others. The study also observed that high levels of Pb in the finger nail or scalp hair had a negative correlation with Ca and Zn. The results of this study will be used to recommend the use of hair and nails as bio-indicators of essential element status as well as environmental exposure to lead instead of blood.**

***Keywords*: Dietary habits, Lead, Essential elements, Human males, Scalp hair, Finger nails, correlation.**

I. INTRODUCTION

There are many risk factors which may increase the exposure of human males to Pb including social demographic risk factors such as age, race/ethnicity, income, education, housing vintage and poverty status among others (Sukumar and Subramanian, 2003; Ndiritu *et al.*, 2012a). The environmental risk factors includes: living near heavy traffic road, 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 dietary habits of males are also a major risk factor to Pb exposure. These factors include: use of glazed ceramics, consumption of canned and highly processed foods, consumption of exposed foods and sources of water among others. There is increased range of human health disorders due to exposure to toxic heavy metals such as lead (Lekouch *et al.*, 1999). Such exposure may emanate from manufacturing industries (where adult males predominate), consumption of exposed foods, consumption of canned foods and use of glazed ceramics (Kahenya, 1996; Owago, 1999) among other lifestyle changes. These risk factors have been reported to exacerbate the absorption of Pb into the bodies of human beings (ATSDR, 2000; Were *et al.*, 2008). 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. Men who are heads of families and bread winners are particularly poor eaters of foods which are considered essential to health (Ndiritu *et al.*, 2012c). Studies on Pb and essential element levels have been reported by Were *et al.* (2008) among school age children using finger nails and in women Owago (1999) using blood. However, no study has reported Pb and essential element levels in the male population. The purpose of this study was to evaluate the influence of dietary habits on essential elements and lead levels in finger nails and scalp hair of adult males in Kenya.

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 and Zn 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.

II. METHODOLOGY

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 Pb and Zn 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 ^oC to a constant weight. The polished finger nail 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.

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. Experimental detection limits of the instrument used for the analysis were 0.011 and 0.00221 for Pb and Zn respectively. 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).

III. RESULTS AND DISCUSSIONS

Influence of Glazed Ceramics use on Mean Metal Levels

The results for the relationship between the mean metal levels and the use of glazed ceramics are presented in Table 1

Table 1: Relationship between mean metal levels and use of glazed ceramics

Parameter	Daily Mean±SE (µg/g)	Occasionally Mean±SE (µg/g)	Not at all Mean±SE (µg/g)	P-value
Pb	222.27±7.59	106.06±8.36	110.49±6.48	0.000
Zn	211.98±5.19	226.88±12.94	217.28±11.33	0.539
Fe	183.43±10.00	170.93±15.39	210.86±33.54	0.441
Ca	739.30±17.27	834.42±31.68	878.37±34.98	0.000
Mg	323.28±10.69	277.19±20.21	364.34±16.98	0.006

Mean values with p-values < 0.05 are significantly different at α=0.05

A positive trend in mean nail and hair Pb levels was associated with increasing frequency of use of glazed ceramics. From Table 1, those who used glazed ceramics frequently had a high mean of 222.27±7.59 µg/g Pb compared to those who used glazed ceramics occasionally at 106.06±8.36 µg/g Pb interestingly those subjects who did not use glazed ceramic at all had a slightly higher Pb levels compared to those who used the glazed ceramics occasionally at 110.49±6.48 µg/g Pb. This could be as a result of false information given by the respondents in the questionnaire. The mean levels of essential elements Ca and Mg differed significantly in subjects who used the ceramics daily, occasionally or not at all. However, the mean levels of Zn and Fe were not significantly different across the subjects irrespective of their glazed ceramics use (Table 1).

Lead (II) oxide is usually added to ceramic materials before firing so as to give them a glaze. This Pb is soluble and is easily extracted by food substance (ATSDR, 1993) leading to gradual bio-accumulation in the bodies of those males who used the glazed ceramics. Generally the solubility of Pb and hence its probability to migrate from the glaze to the food substances is greatest under acidic conditions (ATSDR, 1993; Rahman, 2001; Lehman, 2002). Acidic food substances for example coffee, vinegar, orange juice, wine and carbonated beverages increase the probability of Pb to migrate from the glaze to the food substances. Further, O' Neill (1993) and Owago (1999) reported that scrubbing the ceramics with an abrasive cleanser promotes the migration of Pb from the container to the food they contain. This then accounts for the elevated levels of Pb in males who used glazed ceramics. The findings were in agreement with other studies elsewhere (Owago, 1999; Were *et al.*, 2008; Mogwasi, 2009) who reported significantly higher Pb levels in blood and finger nails of subjects who used glazed ceramics.

Consumption of canned and exposed foods on mean metal levels

The results that show the relationship between the mean metal levels in µg/g and the consumption of canned food are presented in Table 2.

Parameter	Yes Mean±SE (µg/g)	No Mean±SE (µg/g)	P-Value
Pb	205.25±7.70	124.75±6.02	.000
Zn	216.04±5.24	214.11±9.01	.844
Fe	189.59±12.36	186.48±19.94	.890
Ca	765.84±16.90	829.59±28.07	.041
Mg	340.26±10.63	301.26±13.17	.028

Mean values with p-values < 0.05 are significantly different at α=0.05

From Table 2, it can be seen that consumption of highly processed, canned foods with high fat content was significantly associated with high levels of Pb. Those who consumed highly processed and canned food with high fat content frequently had a high mean level of 205.25±7.70 µg/g while those who were non consumers had 124.75±6.02 µg/g Pb. The difference between the levels was statistically significant. Those subjects who did not use highly processed and canned foods had higher levels of Ca than those who consumed possibly because of their elevated Pb levels, the difference was statically significant. The mean levels of Mg was higher in the subjects who consumed highly refined and canned foods than those who did not consume, the means were significantly different. The mean levels of Zn and Fe were higher in the subjects who were consumers than those who were non consumers however the mean levels were not significantly different.

The results that show the relationship between mean metal levels in µg/g and the consumption of exposed foods are presented in Table 3

Table 3: Relationship between mean metal levels and use of exposed foods

Parameter	Yes Mean±SE (µg/g)	No Mean±SE (µg/g)	P-Value
Pb	215.40±7.46	108.50±5.11	.000
Zn	212.02±5.58	221.68±8.13	.319
Fe	186.74±14.91	191.90±12.13	.817
Ca	736.89±15.94	881.50±28.0	.000
Mg	323.66±9.82	333.55±15.56	.574

Mean values with p-values < 0.05 are significantly different at α=0.05

As can be seen from Table 3, consumption of exposed foods from open air markets or streets was found to increase the level of nail and hair Pb. Consumption of exposed food was significantly associated with high levels of lead. Those who consumed exposed foods had a high mean level of 215.40±7.46 µg/g Pb while those who were non consumers of exposed foods had a mean level of 108.50±5.11 µg/g Pb. The difference between these two levels was statistically significant (Table 3). The results showed that subjects from urban areas who frequently consumed exposed food from open air markets (Table 3) had a mean level of 215.40±7.46 µg/g Pb compared to non consumers 108.50±5.11 µg/g Pb. Results of this study are in agreement with the findings of other researchers (Oyaro, 2000; Gaw *et al*., 2006; Nabulo *et al*., 2006) who reported that heavy metals from the environment bio-accumulate in organisms through food chain. In addition they reported that vegetables were the major sinks for air borne toxic metals. Further Oyaro (2000) reported that most of the amaranthus grown and sold in Nairobi and its environs had elevated Pb levels.

Most of the respondents revealed that quite often they ate roasted maize along the roads. This roasted maize, boiled maize, fruits, roasted sweet potatoes among other foods accumulates a lot of dust from the vehicles passing along these roads and since these types of foods are not washed before eating heavy metals may then be ingested together with the food. Dickson *et al.* (2005) found extremely high levels of Pb in soils on the Nairobi highway which was reported as far as 50 m off the road which influenced the levels of Pb in crops cultivated along the road by 10 to 100 times the FAO/WHO maximum tolerable levels of 25 g/kg body weight per week. Oostdam *et al.* (1999) noted that majority of Pb in food originates from atmospheric deposition and to lesser extent from transportation, packaging and preparation process.

Influence of source of water on mean metal levels

Results for the relationship between mean metal levels in µg/g and the type of water used are presented in Table 4

Table 4: Relationship between mean metal levels and the type of water used

Parameter	Tap water Mean±SE (µg/g)	Rain water Mean±SE (µg/g)	Borehole water Mean±SE (µg/g)	P-value
Pb	193.43±7.07	88.13±10.33	169.34±8.23	0.000
Zn	215.51±4.96	289.75±11.85	147.05±10.35	0.000
Fe	185.60±11.10	230.75±53.12	167.57±14.85	0.300
Ca	759.09±15.06	1091.13±40.75	678.07±41.82	0.000
Mg	327.24±9.50	325.75±28.2	327.57±22.49	0.998

Mean values with p-values < 0.05 are significantly different at α=0.05

From Table 4, it can be seen that the source of water was significantly associated with high levels of Pb. Frequent use of water from a certain source was found to have an influence on the level of nail and hair Pb. Those males who depended on tap water had elevated levels of Pb. The mean level was 193.43±7.07 µg/g Pb while those who depended on harvested rain water only had low levels of 88.13±10.33 µg/g Pb. Further, those who depended on the borehole water had slightly elevated levels of 169.34±8.23 µg/g Pb. These mean levels of Pb for the different type of water used were found to be statistically significant at α=0.05.

It was also established that whether the subject came from urban or rural area, their mean levels of Pb were greatly influenced by the type of water used. The study established that the type of water influenced the levels of essential elements for example Zn and Ca. The study established that there were significant differences in the levels of Zn and Ca for the different types of water that the subjects consumed. The subjects from urban setting who frequently used tap water were associated with significant high levels of lead. Males who frequently used harvested rain water from rural areas were associated with low levels of nail and hair lead compared to those who used borehole or tap water. The results of this study were not surprising as Pb could have probably come from the plumbing system as it was reported by UNEP (2001) and agrees with results of CDC (2005) which reported that use of galvanized pipes in water distribution system increased levels of lead by 5-10 folds in drinking water. Results are in agreement with other studies done elsewhere (Were *et al.*, 2008).

It was further found that the subjects who used harvested rain water were associated with lower levels of lead compared to those who used borehole water. This result could probably explain the association of low levels of Pb in ambient air in the rural areas. The subjects who frequently consumed borehole water were found to have slightly elevated levels of nail and hair Pb which could probably be due to runoff principally containing heavy metals from fertilizers and pesticides used by farmers in this horticultural growing zone and erosion from the weathering rocks. Results of this study are in agreement with findings of studies done elsewhere (Mehra and Juneja, 2005; Segura-Munoz *et al.*, 2006). The study established negative correlation between Pb and essential elements in nails and hair from rural and urban settings Human males and general public should be advised accordingly on proper eating habits to ensure that they have higher levels of essential elements. This will go a long way in reducing the chances of Pb absorption.

IV .CONCLUSIONS

From the results obtained, it can be concluded as follows:

- i. Use of glazed ceramics led to increased. absorption of Lead into the body system
- ii. Consumption of canned and exposed foods is associated with increased Lead levels.
- iii. Consumption of tap water leads to accumulation of Lead into human bodies.
- iv. The elevated Lead levels led to reduced levels of essential elements in either case, the levels of Pb and essential elements were found to be significantly different.

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