



Metals in Hair as Predictors of Disease

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Background

The link between metal concentrations in hair and human health effects has been shown in previously published literature. Bencko et al. (1986) determined that the best means of determining pollution's effect humans is to measure hair samples. The variability in air and water is too high, and hair is easy to store and transport. He concluded that hair analysis is an essential tool for measuring hazardous emissions of trace elements. Srogi (2006) also found that concentrations of elements in hair samples are a good indicator of metal exposure. This research opened the door to screening individuals and populations for metal exposure through hair sampling.

Objective

Our project aims to determine how increased levels of metals in hair samples contribute to human health. In collaboration with the University of Eastern Finland - Kuopio we are building upon the work of the Kuopio Ischemic Heart Disease (KIHD) study to determine if there are any indicators of future health implications from metal concentrations in hair samples. Particularly, we wish to establish correlations between specific metals and conditions that they may contribute to.

Methods

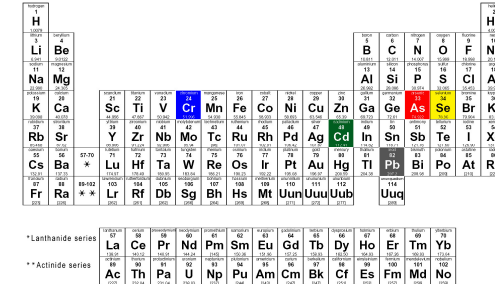
We measured concentrations of heavy metals in 67 hair samples collected in 1985-86 in Finland during baseline testing in the KIHD study. Hair samples were collected in Finland as part of Dr. Crispin Pierce's Fulbright research and were analyzed by other students at UWEC using Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

To determine disease risk, we utilized the biological data gathered during the KIHD study during their 20 years of follow up. The biological data consists of health markers, disease diagnoses, and test results for each individual.

The hair metal concentration data set consists of the results of each hair samples analysis for concentrations of 8 different metal isotopes: Lead 206 and 208, Chromium 52 and 53, Cadmium 111 and 114, Arsenic 75, and Selenium 77 (See Figure).

Regressions and t-tests were performed using Microsoft Excel® software. The majority of hair metal concentrations data was right-skewed so the log of hair metal concentrations was taken in order to achieve a normal. A correlation chart was created to generate correlation coefficients (R^2 values). The regression analyses that generated p-values <0.05 were considered significant (see Table). We conducted t-tests comparing the means of hair metal concentrations for health markers with binary results using the log metal concentrations against the discrete variables present in the health data. P-values <0.05 were again considered significant (see Table).

Figure



Table

Log of Concentration of Metal Isotope	Biological Data	P-Value
Arsenic	Diabetes >6 mmol/L	0.0411
Arsenic	Hair mercury level >2 µg/g	0.0153
Arsenic	Weakness in legs in 12 months	0.0099
Arsenic	Strain in ankles at work	0.0188

Log of Concentration of Metal Isotope	Biological Data	P-Value
Cadmium 111	Neurological problem	0.0413
Cadmium 111	Phlegm in winter	0.0153
Cadmium 111	Weakness in 12 months	0.0378
Cadmium 111	Hair mercury level (µg/g)	0.0020
Cadmium 114	Angina Pectoris	0.0170
Cadmium 111	Strain in wrists at work	0.0294
Cadmium 114		0.0355
Cadmium 114	Chronic bronchitis diagnosed after baseline	0.0425
Cadmium 114	Diabetes >8 mmol/L	0.00136
Cadmium 114	Angina Pectoris	0.00371
Cadmium 114	Diabetes	0.00136
Cadmium 114	Diabetes >6.7 mmol/L	0.00136
Cadmium 114	Diabetes >6 mmol/L	0.0014
Cadmium 114	Smoking	0.0090

Log of Concentration of Metal Isotope	Biological Data	P-Value
Chromium 52	Alcoholism	0.0345
Chromium 52	Phlegm in winter	0.0028
Chromium 53		0.0147
Chromium 52	Hemoglobin (g/L)	0.0289
Chromium 53		0.0210
Chromium 52	Leukocytes (10 ⁹ /L)	0.0135
Chromium 53		0.0367

Log of Concentration of Metal Isotope	Biological Data	P-Value
Lead 206	Chronic bronchitis	0.0223
Lead 206	Pneumonia	0.0227
Lead 206	Neurological problem	0.0481
Lead 206	Phlegm in winter	0.0258
Lead 208		0.0335
Lead 206	Strain in wrists at work	0.00029
Lead 208		0.00239
Lead 206	Strain in arms at work	0.0304
Lead 208		0.0317
Lead 206	Strain in ankles at work	0.0245
Lead 208		0.0263
Lead 206	Hematocrit Level	0.0590
Lead 208		0.0552
Lead 208	Cardiovascular Disease Death before 2010	0.0439

Log of Concentration of Metal Isotope	Biological Data	P-Value
Selenium	Respiratory cancer death	0.0453
Selenium	Lung cancer death	0.0453
Selenium	Cardiovascular disease death before 1996	0.0480
Selenium	Cardiovascular disease death before 1999	0.0240
Selenium	Cardiovascular disease death before 2002	0.0443

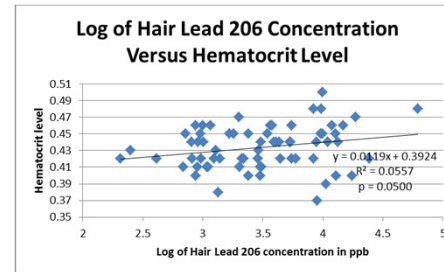
Results

Chromium and Phlegm in Winter Mornings:

Both isotopes of Chromium (logCr52 and logCr53) were significantly and positively correlated to phlegm on winter mornings (p-values equal to 0.0028 and 0.0147 respectively). As early as 1827, chromium exposure has been linked to nasal and respiratory diseases (Bloomfield, 1928). Respiratory effects of chromium include irritation of nasal passages, and runny nose or increased production of mucus (ASTDR, 2012).

Lead and Hematocrit:

When graphed, both isotopes of Lead (logPb206, and logPb208) were significantly and positively correlated with hematocrit level. Hematocrit, the proportion of blood volume made up of red blood cells, has been previously found to increase with long-term exposure to lead (Hsiao, 2001). The log of Lead 206 was positively correlated with hematocrit with an R^2 value of 0.0557 and a p-value of 0.0500 (see graph below). The relationship between the log of lead 208 and hematocrit was less significant with an R^2 value of 0.0554 and a p-value of 0.0552.



Lead and Hematocrit levels positively and significantly correlate with a p-value equal to 0.0500, which is at the cutoff point for significance. The graph indicates that as lead levels in hair samples increase, the hematocrit level tends to increase as well. These findings are supported by previously published literature (Hsiao, 2001).

Conclusions

- The relationships between lead and hematocrit as well as chromium and phlegm in winter mornings were both significantly and positively correlated, and are relationships supported by previously published literature.
- A number other hair metal concentrations are significantly correlated with a variety of health markers. Some relationships were contradicted and other supported by previously published literature.
- More research should be done to further increase understanding as to how increased heavy metal load in the body contributes to disease risk or decreased functioning in a wide range of body systems.
- Future analysis of this data is planned. Analyzing more hair samples will increase significance and strengthen conclusions about the correlations.

References

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Significant Correlations Arranged by Metal