

NHANES 1999–2000 Public Release Dataset

Revised July 2004

Lab 06HM – Urinary Barium, Beryllium, Cadmium, Cobalt, Cesium, Molybdenum, Lead, Platinum, Antimony, Thallium, and Tungsten

Description

Urinary Barium, Beryllium, Cadmium, Cobalt, Cesium, Molybdenum, Lead, Platinum, Antimony, Thallium, and Tungsten

Trace metals have been associated with adverse health effects in occupational studies or laboratory studies, but have not been monitored in general population groups. Information on levels of exposure to these compounds is essential to determine the need for regulatory mechanisms to reduce the levels of hazardous pollutants to which the general population is exposed and to establish population-based reference intervals for several potentially toxic metals.

Eligible Sample

Eligible participants were aged 6 years and older, met the subsample criteria, and did not meet any of the exclusion criteria.

Data Collection

Urine specimens were processed, stored, and shipped to the Division of Environmental Health Laboratory Sciences, National Center for Environmental Health, Centers for Disease Control and Prevention for analysis.

Examination Protocol

Detailed specimen collection and processing instructions are discussed in the NHANES Laboratory/Medical Technologists Procedures Manual (LPM). Vials were stored under appropriate frozen (-20°C) conditions until they were shipped to the National Center for Environmental Health for testing.

Analytic Methodology

Urinary Barium, Beryllium, Cadmium, Cobalt, Cesium, Molybdenum, Lead, Platinum, Antimony, Thallium, and Tungsten

Inductively coupled plasma mass spectrometry (ICP-MS) is a multi-element analytical technique.¹ Liquid samples are introduced into the ICP through a nebulizer and spray chamber carried by a flowing argon stream. By coupling radio frequency power into

flowing argon, a plasma is created in which the predominant species are positive argon ions and electrons. The sample passes through a region of the plasma having a temperature of 6000! 8000 K. The thermal energy atomizes the sample, then ionizes the atoms. The ions, along with the argon, enter the mass spectrometer through the interface that separates the ICP, which is operating at atmospheric pressure, from the mass spectrometer, which is operating at a pressure of 10^{-6} torr. The mass spectrometer permits detection of ions at each mass in rapid sequence, allowing individual isotopes of an element to be determined. Electrical signals resulting from the detection of the ions are processed into digital information which is used to indicate the intensity of the ions and subsequently the concentration of the element. A total of 15 elements, including Be, Mn, Co, Ni, Mo, Sn, Sb, Cs, Ba, W, Pt, Tl, and Pb, are measured in urine by ICP-MS based on the method by Kevin J. Mulligan et al.² Urine samples are diluted 1:9 with 2% (v/v) (GFS Chemicals, Columbus, OH) double-distilled concentrated nitric acid containing both iridium and rhodium for multi-internal standardization. This procedure may be used for all 15 elements or subsets of the 15 elements.

This method is used to achieve rapid and accurate quantification of multiple elements of toxicological and nutritional interest. The method is sensitive enough to be used to rapidly screen urine specimens from subjects suspected to be exposed to a number of important toxic elements or to evaluate environmental or other non-occupational exposure to these same elements.

Special Note Regarding Urine Cadmiums

Urine cadmium levels are corrected for interference from molybdenum oxide. The original data release did not include this correction. The variable name for the corrected cadmium levels is URDUCD. The formula for the correction is:

$$\text{URDUCD} = \text{URXUCD} - ((0.00175 * \text{URXUMO}) - 0.0136)$$

where URXUCD is the original value for the cadmium result. Corrected values that are less than zero are recoded to equal zero. If the result for urine molybdenum is missing, then the result for the corrected cadmium result is also missing.

The corrected data set also includes a variable URDUCDLC to indicate which results were below the limit of detection. For results below the limit of detection, the corrected value was calculated using the detection limit for urinary cadmium divided by the square root of 2 (value = 0.04).

See below for further explanation of this correction.

Effect of Molybdenum Oxide on Urine Cadmium Results

The ICP-MS methods for the determination of urine cadmium have not been corrected for a possible interference from molybdenum oxide, MoO. Because the historical Proficiency Testing (PT) results for urine Cd were well within expected ranges and no consistent bias was observed with these PT samples that included several years of challenges, it was thought that, at typical biological molybdenum levels and typical instrumental oxide levels, the interference would not be significant. Upon investigation with more than 6000 NHANES samples analyzed, we were able to see a possible effect on the urine Cd results when the results for the urine Cd versus Mo concentration were plotted. This effect cannot be easily seen with a few hundred sample results. Upon further investigation, we determined that the historical NHANES urine Cd results were biased high. A first-order approximation of the effect of this interference, for example, was determined to be at the 50th percentile for urine Cd 0.33 µg/L (without correcting for the MoO interference) versus 0.19 µg/L (with the correction). Therefore, we started to investigate how to best implement a revised analytical method to eliminate this interference. In addition, until DLS had received and implemented some new ICP-MS technology, we could not have eliminated this interference using the traditional ICP-MS technologies. We have recently implemented this new technology (Dynamic Reaction Cell [DRC] technology) and have been able to develop a revised analytical method which allows us to correct for this MoO interference.

We performed a method comparison using 208 samples that included the typical range of Cd and Mo concentrations in urine. The results are shown in Equation (1), where $(Cd_{Std\ Method} - Cd_{Corrected\ Method})$ is plotted versus the urine molybdenum concentration. $Cd_{Std\ Method}$ is the non-DRC method, and $Cd_{Corrected\ Method}$ is the DRC method. The best-fit regression line had an $r^2 = 0.81$ and is given by Equation (1):

$$(Cd_{Std\ Method} - Cd_{Corrected\ Method}) = 0.00175 (Mo) - 0.01360 \quad (1)$$

Equation (2) is the adjustment equation used to correct the Standard Method results to the new Corrected Method (the new DRC method). $Cd_{Corrected\ Method} = Cd_{Std\ Method} - (0.00175 * (Mo) + 0.01360$

$$UCd_{Corrected\ Method} = UCd_{Std\ Method} - (0.00175 * (UMO) + 0.01360) \quad (2)$$

Special Notes for this Dataset

The analysis of NHANES 1999–2000 laboratory data must be conducted with the key survey design and basic demographic variables. The NHANES 1999–2000 Household Questionnaire Data Files contain demographic data, health indicators, and other related information collected during household interviews. The Household Questionnaire Data Files also contain all survey design variables and sample weights required to analyze these data. The Phlebotomy Examination file includes auxiliary information on duration of fasting, the time of day of the venipuncture, and the conditions precluding venipuncture. The Household Questionnaire and Phlebotomy Exam files may be linked to the laboratory data file using the unique survey participant identifier SEQN.

Special Sample Weights for this Dataset

Special sample weights are required to analyze these data properly. Please check the Analytic Guidelines posted for the file on the NHANES website.

References

1. Date, AR, and Gray, AL. Applications of Inductively Coupled Plasma Mass Spectrometry. New York: Chapman and Hall; 1989.
2. Mulligan, KJ, Davidson, TM, and Caruso, JA. Feasibility of the direct analysis of urine by inductively coupled argon plasma mass spectrometry for biological monitoring of exposure to metals. J Anal At Spectrom. 1990;5:301.