National Health and Nutrition Examination Survey 2003-2004

Documentation, Codebook, and Frequencies

Laboratory Component:
Total and Speciated Arsenics

Survey Years:
2003 to 2004

SAS Export File:
L06UAS_C.XPT

First Release: November 2007
Last Revised: N/A

NHANES 2003–2004 Data Documentation

Laboratory Assessment: Lab 06 - Urinary Total Arsenic and Speciated Arsenics

(arsenobetaine, arsenocholine, trimethylarsine oxide, monomethylarsonic acid, dimethylarsinic acid, arsenous (III) acid, arsenic (V) acid)

First Published: November 2007 **Last Revised:** N/A

Component Description

Arsenic is widely distributed in the earth's crust and is found most often in ground water rather than surface water. People encounter arsenic in many chemical forms that vary greatly in toxicity. The most toxic of the naturally-occurring arsenic compounds are inorganic forms of arsenic and their methylated metabolites. Less toxic are the organic arsenic compounds. Although this method does not reveal the chemical form of arsenic to which a person is exposed, it is sensitive enough to screen urine specimens rapidly from people thought to be exposed to arsenic or to evaluate total environmental or other total non-occupational exposure to arsenic.

Eligible Sample

Participants aged 6 years and older who met the subsample requirements.

Description of Laboratory Methodology

1. Total arsenic

The method described in this manual assesses arsenic exposure by analyzing urine through the use of inductively coupled-plasma dynamic reaction cell-mass spectrometry (ICP-DRC-MS). Urine is analyzed because urinary excretion is the major pathway for eliminating arsenic from the mammalian body[1]. This method achieves rapid and accurate quantification of total urinary arsenic.

Total urine arsenic concentrations are determined by using ICP-DRC-MS. This multielement analytical technique is based on quadrupole ICP-MS technology[2] and includes DRC™ technology[3], which minimizes or eliminates much argon-based polyatomic interference. Coupling radio frequency power into a flowing argon stream seeded with electrons creates the plasma, the heat source, which is ionized gas suspended in a magnetic field. Predominant species in the plasma are positive argon ions and electrons. Diluted urine samples are converted into an aerosol by using a nebulizer inserted within a spray chamber. A portion of the aerosol is transported through the spray chamber and then through the central channel of the plasma, where it is exposed to

temperatures of 6000-8000 K. This thermal energy atomizes and ionizes the sample. The ions and the argon enter the mass spectrometer through an interface that separates the ICP, which is operating at atmospheric pressure (approximately 760 torr), from the mass spectrometer, which is operating at approximately 10-5 torr. The mass spectrometer permits detection of ions at each mass-to-charge ratio in rapid sequence, which allows the determination of individual isotopes of an element. Once inside the mass spectrometer, the ions pass through the ion optics, then through DRC™, and finally through the mass-analyzing quadrupole before being detected as they strike the surface of the detector. The ion optics uses an electrical field to focus the ion beam into the DRC™. The DRC™ component is pressurized with an appropriate reaction gas and contains a quadrupole. In the DRC™, elimination or reduction of argon-based polyatomic interferences takes place through the interaction of the reaction gas with the interfering polyatomic species in the incoming ion beam. The quadrupole in the DRC™ allows elimination of unwanted reaction by-products that would otherwise react to form new interferences. Electrical signals resulting from the detection of the ions are processed into digital information that is used to indicate the intensity of the ions and subsequently the concentration of the element. In this method, arsenic (isotope mass 75) and gallium (isotope mass 71) or tellurium (isotope mass 126) is measured in urine by ICP-DRC-MS using argon/hydrogen (90%/10%, respectively) as a reaction gas[4]. Urine samples are diluted 1:9 with 2% (v/v) double-distilled nitric acid containing gallium or tellurium for internal standardization.

2. Speciated arsenics (arsenobetaine, arsenocholine, trimethylarsine oxide, monomethylarsonic acid, dimethylarsinic acid, arsenous (III) acid, arsenic (V) acid)

The concentration of speciated arsenics are determined by using high performance liquid chromatography (HPLC) to separate the species coupled to an ICP-DRC-MS to detect the arsenic species. This analytical technique is based on separation by anion-exchange chromatography (IC) followed by detection using quadrupole ICP-MS technology and includes DRC™ technology[5], which minimizes or eliminates many argon-based polyatomic interferences[6] will require 0.5 mL of urine. Arsenic species column separation is largely achieved due to differences in charge-charge interactions of each negatively-charged arsenic component in the mobile phase with the positively-charged quaternary ammonium groups bound at the column's solid-liquid interface. Upon exit from the column, the chromatographic eluent goes

through a nebulizer where it is converted into an aerosol upon entering the spray chamber.

Carried by a stream of argon gas, a portion of the aerosol is transported through the spray chamber and then through the central channel of the plasma, where it is heated to temperatures of 6000-8000° K. This thermal energy atomizes and ionizes the sample. The ions and the argon enter the mass spectrometer through an interface that separates the ICP, which is operating at atmospheric pressure (approximately 760 torr), from the mass spectrometer, which is operating at approximately 10-5 torr.

The mass spectrometer permits detection of ions at each mass-to-charge ratio in rapid sequence, which allows the determination of individual isotopes of an element. Once inside the mass spectrometer, the ions pass through the ion optics, then through the DRC™, and finally through the mass-analyzing quadrupole before being detected as they strike the surface of the detector. The ion optics uses an electrical field to focus the ion beam into the DRC™.

The DRC™ component is pressurized with an appropriate reaction gas and contains a quadrupole. In the DRC™, elimination or reduction of argon-based polyatomic interferences takes place through the interaction of the reaction gas with the interfering polyatomic species in the incoming ion beam. The quadrupole in the DRC™ allows elimination of unwanted reaction by-products that would otherwise react to form new interferences.

Laboratory Quality Control and Monitoring

Urine specimens are 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.

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

Mobile Examination Centers (MECs)
Laboratory team performance is monitored using several techniques. NCHS and contract consultants use a structured quality assurance

evaluation during unscheduled visits to evaluate both the quality of the laboratory work and the quality-control procedures. Each laboratory staff person is observed for equipment operation, specimen collection and preparation; testing procedures and constructive feedback are given to each staff. Formal retraining sessions are conducted annually to ensure that required skill levels were maintained.

The NHANES QA/QC protocols meet the 1988 Clinical Laboratory Improvement Act mandates. Detailed QA/QC instructions are discussed in the NHANES LPM.

Analytical Laboratories

NHANES uses several methods to monitor the quality of the analyses performed by the contract laboratories. In the MEC, these methods include performing blind split samples collected on “dry run” sessions. In addition, contract laboratories randomly perform repeat testing on 2.0% of all specimens.

NCHS developed and distributed a quality control protocol for all the contract laboratories which outlined the Westgard rules used when running NHANES specimens. Progress reports containing any problems encountered during shipping or receipt of specimens, summary statistics for each control pool, QC graphs, instrument calibration, reagents, and any special considerations are submitted to NCHS and Westat quarterly. The reports are reviewed for trends or shifts in the data. The laboratories are required to explain any identified areas of concern.

All QC procedures recommended by the manufacturers were followed. Reported results for all assays meet the Division of Laboratory Science’s quality control and quality assurance performance criteria for accuracy and precision (similar to specifications outlined by Westgard (1981).

Analytic Notes

Subsample weights

Measures of urinary speciated arsenic were measured in a one-third subsample of persons 6 years and over. Special sample weights(WTSA2YR) are required to analyze these data properly. Specific sample weights for this subsample are included in this data file and should be used when analyzing these data.

Variance estimation
The analysis of NHANES 2003-2004 laboratory data must be conducted with the key survey design and basic demographic variables. The NHANES 2003-2004 Demographic Data File contains demographic and sample design variables. The recommended procedure for variance estimation requires use of stratum and PSU variables (SDMVSTRA and SDMVPSU, respectively) in the demographic data file.

Links to NHANES Data Files
This laboratory data file can be linked to the other NHANES 2003-2004 data files using the unique survey participant identifier SEQN.

Detection Limits
The detection limits were constant for all of the arsenics in the data set.

Lower detection limits for the total and speciated arsenics	
Urinary total arsenic	0.6 µg/L
Urinary arsenous acid	1.2 µg/L
Urinary Arsenic acid	1.0 µg/L
Urinary Arsenobetaine	0.4 µg/L
Urinary Arsenocholine	0.6 µg/L
Urinary Dimethylarsonic acid	1.7 µg/L
Urinary Monomethylacrsonic acid	0.9 µg/L
Urinary Trimethylarsine Oxide	1.0 µg/L

Two variables are provided for each of these analytes. The variable named URD___LC indicates whether the result was below the limit of detection. There are two values: “0” and “1”. “0” means that the result was at or above the limit of detection. “1” indicates that the result was below the limit of detection.

The other variable named URX___ provides the analytic result for that analyte.

Please refer to the Analytic Guidelines for further details on the use of

sample weights and other analytic procedures.

References

1. Vahter ME. Arsenic. In: Clarkson T W, Friberg L, Nordberg G F, Sager P R, editors. Biological monitoring of toxic metals. New York: Plenum Press, 1988. p.303-21.
2. Date AR, Gray AL. Applications of inductively coupled plasma-mass spectrometry. New York: Chapman and Hall; 1989.
3. Tanner SD, Baranov VI. Theory, design and operation of a DRC™ for ICP-MS. Atomic Spectroscopy 1999; 20(2):45-52.
4. Neubauer K. Vollkopf U. The benefits of a DRC™ to remove carbon- and chloride-based spectral interferences by ICP-MS. Atomic Spectroscopy 1999; 20(2):64-8.
5. Baranov VI, Tanner SD. A dynamic reaction cell for inductively coupled plasma mass spectrometry (ICP-DRC-MS). Part 1. The rf-field energy contribution in thermodynamics of ion-molecule reactions. J. Anal. At. Spectrom. 1999;14:1133-1142.
6. Tanner S, Baranov VI, Vollkopf U. A dynamic reaction cell for inductively coupled plasma mass spectroscopy (ICP-DRC-MS). Part III. Optimization and analytical performance. J. Anal. At. Spectrom. 2000;15:1261-1269.

Locator Fields

Title: Urinary Total Arsenic and Speciated Arsenics

Contact Number: 1-866-441-NCHS

Years of Content: 2003–2004

First Published: November 2007

Revised: N/A

Access Constraints: None

Use Constraints: None

Geographic Coverage: National

Subject: Urinary Total Arsenic and Speciated Arsenics

Record Source: NHANES 2003–2004

Survey Methodology: NHANES 2003–2004 is a stratified multistage probability sample of the civilian non-institutionalized population of the U.S.

Medium: NHANES Web site; SAS transport files

National Health and Nutrition Examination Survey
Codebook for Data Production (2003-2004)

Total and Speciated Arsenics (L06UAS_C)
Person Level Data

First Published: November 2007
Last Revised: N/A

SEQN	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Respondent sequence number
English Text: Respondent sequence number.	
English Instructions:	

WTSA2YR	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Two-year MEC weights of subsample A
English Text: Two-year MEC weights of subsample A	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0 to 455771.88304	Range of Values	2673	2673	
.	Missing	0	2673	

URXUCR	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Creatinine, urine (mg/dL)
English Text: Creatinine, urine (mg/dL)	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
6 to 768	Range of Values	2586	2586	
.	Missing	87	2673	

URXUAS	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary total Arsenic (ug/L)
English Text: Urinary total Arsenic (ug/L)	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0.4 to 1221.2	Range of Values	2557	2557	
.	Missing	116	2673	

URDUASLC	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary total Arsenic comment code
English Text: Urinary total Arsenic comment code	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0	At or above the detection limit	2529	2529	
1	Below lower detection limit	28	2557	
.	Missing	116	2673	

URXUAS3	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Arsenous acid (ug/L)
English Text: Urinary Arsenous acid (ug/L)	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0.8 to 23	Range of Values	2573	2573	
.	Missing	100	2673	

URDUA3LC	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Arsenous acid comment code
English Text: Urinary Arsenous acid comment code	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0	At or above the detection limit	137	137	
1	Below lower detection limit	2436	2573	
.	Missing	100	2673	

URXUAS5	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Arsenic acid (ug/L)
English Text: Urinary Arsenic acid (ug/L)	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0.7 to 8.8	Range of Values	2573	2573	
.	Missing	100	2673	

URDUA5LC	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Arsenic acid comment code
English Text: Urinary Arsenic acid comment code	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0	At or above the detection limit	167	167	
1	Below lower detection limit	2406	2573	
.	Missing	100	2673	

URXUAB	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Arsenobetaine (ug/L)
English Text: Urinary Arsenobetaine (ug/L)	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0.3 to 1011.3	Range of Values	2573	2573	
.	Missing	100	2673	

URDUABLC	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Arsenobetaine comment code
English Text: Urinary Arsenobetaine comment code	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0	At or above the detection limit	1716	1716	
1	Below lower detection limit	857	2573	
.	Missing	100	2673	

URXUAC	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Arsenocholine (ug/L)
English Text: Urinary Arsenocholine (ug/L)	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0.4 to 9.4	Range of Values	2573	2573	
.	Missing	100	2673	

URDUACLC	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Arsenocholine comment code
English Text: Urinary Arsenocholine comment code	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0	At or above the detection limit	41	41	
1	Below lower detection limit	2532	2573	
.	Missing	100	2673	

URXUDMA	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Dimethylarsonic acid (ug/L)
English Text: Urinary Dimethylarsonic acid (ug/L)	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
1.2 to 71	Range of Values	2573	2573	
.	Missing	100	2673	

URDUDALC	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Dimethylarsonic acid comment
English Text: Urinary Dimethylarsonic acid comment code	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0	At or above the detection limit	2248	2248	
1	Below lower detection limit	325	2573	
.	Missing	100	2673	

URXUMMA	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Monomethylacrsonic acid (ug/L)
English Text: Urinary Monomethylacrsonic acid (ug/L)	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0.6 to 16	Range of Values	2572	2572	
.	Missing	101	2673	

URDUMMAL	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Monomethylacrsonic acid comment
English Text: Urinary Monomethylacrsonic acid comment code	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0	At or above the detection limit	931	931	
1	Below lower detection limit	1641	2572	
.	Missing	101	2673	

URXUTM	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Trimethylarsine Oxide (ug/L)
English Text: Urinary Trimethylarsine Oxide (ug/L)	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0.7 to 27	Range of Values	2573	2573	
.	Missing	100	2673	

URDUTMLC	Target
	B(6 Yrs. to 150 Yrs.)
Hard Edits	**SAS Label**
	Urinary Trimethylarsine Oxide comment
English Text: Urinary Trimethylarsine Oxide comment code	
English Instructions:	

Code or Value	Description	Count	Cumulative	Skip to Item
0	At or above the detection limit	12	12	
1	Below lower detection limit	2561	2573	
.	Missing	100	2673	