# National Health and Nutrition Examination Survey

## August 2021-August 2023 Data Documentation, Codebook, and Frequencies

## Mercury: Inorganic, Ethyl, and Methyl - Blood (IHGEM_L)

**Data File: IHGEM_L.xpt**

**First Published: September 2024**

**Last Revised: NA**

---

## Component Description

**Inorganic, Ethyl and Methyl Mercury**

Uncertainties exist regarding levels of exposure to methyl mercury from fish consumption and potential health effects resulting from this exposure. Past estimates of exposure to methyl mercury have been obtained from results of food consumption surveys and measures of methyl mercury in fish. Measures of a biomarker of exposure are needed for improved exposure assessments.

Blood measures of total and inorganic mercury are important for evaluating exposure to mercury in interior latex paints.

## Eligible Sample

All examined participants aged 1 year and older were eligible.

## Description of Laboratory Methodology

**Inorganic, Ethyl and Methyl Mercury**

The quantification of InHg, MeHg, and EtHg in whole blood samples is performed using a triple spike isotope dilution (TSID) method employing gas chromatography (GC) to separate the species followed by introduction into an ICP-DRC-MS for detection. TSID is a specialized extension of the Isotope Dilution (ID) technique. TSID measures individual chemical species (inorganic, methyl and ethyl mercury species) in samples using ID principles. The blood sample is spiked with known amounts of each Hg species that have been enriched with isotopic variants of the target element of interest.

The first step of this method involves the addition ("spiking") of enriched isotopes ($^{199}Hg^{2+}$, $CH_3{}^{200}Hg^{+}$, and $C_2H_5{}^{201}Hg^{+}$ or $C_2H_5{}^{198}Hg^{+}$, $^{199}Hg^{2}$, and $CH_3{}^{201}Hg^{+}$) to the blood sample. Each Hg species spike is labeled with an enriched Hg isotope such that its isotopic pattern is unique to the species' chemical identity (i.e. the manner of isotope spiking is "species specific"). Next, the spiked sample is digested in tetramethylammonium hydroxide (TMAH) which disassociates bound mercury species from proteins, polypeptides, and other biomolecules. The digested blood sample with freed mercury species is chemically reacted ("derivatized") with a reagent that adds 3-carbon chains (n-propyl groups) to the mercury atom of each species molecule without compromising species identity. This type of chemical derivatization results in loss of ionic charge and reduced polarity making each mercury species

molecule volatile so that it can escape the liquid phase and accumulate in the gaseous phase ("headspace") directly above the sample. Derivatization is performed inside a partially filled vial sealed with a rubber septa cap that can be penetrated by a needle.

Solid Phase Microextraction (SPME) is a sampling technique that uses a thin polymer fiber with a hydrophobic coating. The method described here uses a SPME fiber with a 100 µm coating of polydimethylsiloxane (PDMS). The SPME assembly consists of the fiber inserted in a stainless-steel needle. A key design feature is that the fiber can be mechanically withdrawn into the needle during vial septum penetration and then pushed out to expose the fiber to the headspace. During headspace exposure (the "extraction" step), the gaseous derivatized Hg species adsorbs onto the PDMS coating of the SPME fiber. When other factors are held constant, the adsorbed mass increases as a function of sample concentration. After a predetermined time, the SPME fiber is retracted into the injection needle, and the needle is withdrawn from the sample vial. Subsequently, the needle moves to the injector port of the programmable temperature gradient gas chromatograph, (GC) and on programmatic command, performs a programmed temperature ramp injection sequence. This action transfers the propylated inorganic, methyl and ethyl Hg species to the head of a 30 m capillary GC column which, using He as the carrier gas, ramps the column temperature to 280°C. The order of chromatographic separation of the Hg species is based on increasing molecular weight: methylpropylmercury (derivatized methyl Hg), ethylpropylmercury (derivatized ethyl Hg), followed by dipropylmercury (derivatized inorganic Hg). Hg species exiting the GC column are seen as chromatographic peaks detected using an inductively coupled argon plasma (ICP) as the ion source and a quadrupole mass spectrometer (MS) for mass specific quantification. Species identification is based on chromatographic retention time. Sspecies-specific isotope ratios are calculated from integrated peak areas derived from m/z signals corresponding to $^{199}$Hg, $^{200}$Hg, $^{201}$Hg, and $^{202}$Hg isotopes or $^{198}$Hg, $^{199}$Hg, $^{201}$Hg, and $^{202}$Hg isotopes. The ICP-MS is equipped with a Dynamic Reaction Cell (DRC™) for minimizing polyatomic interferences. Operating the ICP-MS in DRC mode has an added benefit of enhancing Hg signal strength through an effect known as "collisional focusing" (Baranov, et. al.,1999 and Tanner et. al., 2000).

Refer to the Laboratory Method Files section for a detailed description of the laboratory methods used.

There were no changes to lab methods, lab equipment, or lab site for this component in the NHANES August 2021–August 2023 cycle.

## Laboratory Method Files

Mercury: Inorganic, Ethyl, and Methyl - Blood (September 2024)

## Laboratory Quality Assurance and Monitoring

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

Detailed instructions on specimen collection and processing are discussed in the NHANES Laboratory Procedures Manual (LPM). Vials are stored under appropriate frozen (–30°C) conditions until they are shipped to National Center for Environmental Health for testing.

The NHANES quality assurance and quality control (QA/QC) protocols meet the 1988 Clinical Laboratory Improvement Amendments mandates. Detailed QA/QC instructions are discussed in the NHANES LPM.

**Mobile Examination Centers (MECs)**

Laboratory team performance is monitored using several techniques. NCHS and contract consultants use a structured competency assessment evaluation during visits to evaluate both the quality of the laboratory work and the QC procedures. Each laboratory staff member is observed for equipment operation, specimen collection and preparation; testing procedures and constructive feedback are given to each staff member. Formal retraining sessions are conducted annually to ensure that required skill levels were maintained.

**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% of all specimens.

NCHS developed and distributed a QC protocol for all the contract laboratories, which outlined the use of Westgard rules (Westgard et. al., 1981) when testing 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 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 Sciences' QA/QC performance criteria for accuracy and precision, similar to the Westgard rules (Caudill, et. al., 2008).

## Data Processing and Editing

The data were reviewed. Incomplete data or improbable values were sent to the performing laboratory for confirmation.

Three calculated variables were created in this data file. The variable were created using the following formulas:

**LBDIHG:** The inorganic mercury value in µg/L (LBXIHG) was converted to nmol/L (LBDIHGSI) by multiplying LBXIHG by 4.99 (Round to 2 decimal points).

**LBDBGE:** The ethyl mercury value in µg/L (LBXBGE) was converted to nmol/L (LBDBGE) by multiplying LBXBGE by 4.99 (Round to 2 decimal points).

**LBDBGM:** The methyl mercury value in µg/L (LBXBGM) was converted to nmol/L (LBDBGM) by multiplying LBXBGM by 4.99 (Round to 2 decimal points).

## Analytic Notes

There are over 800 laboratory tests performed on NHANES participants. However, not all participants provided biospecimens or enough volume for all the tests to be performed. The specimen availability can also vary by age or other population characteristics. Analysts should evaluate the extent of missing data in the dataset related to the outcome of interest as well as

any predictor variables used in the analyses to determine whether additional re-weighting for item non-response is necessary.

Please refer to the NHANES Analytic Guidelines and the on-line NHANES Tutorial for further details on the use of sample weights and other analytic issues.

**Phlebotomy Weights**

For the August 2021-August 2023 cycle, analysis of nonresponse patterns for the phlebotomy component in the MEC examination revealed differences by age group and race/ethnicity, among other characteristics. For example, approximately 67% of children aged 1-17 years who were examined in the MEC provided a blood specimen through phlebotomy, while 95% of examined adults aged 18 and older provided a blood specimen. Therefore, an additional phlebotomy weight, WTPH2YR, has been included in this data release to address possible nonresponse bias. Participants who are eligible but did not provide a blood specimen have their phlebotomy weight assigned a value of "0" in their records. The phlebotomy weight should be used for analyses that use variables derived from blood analytes, and is included in all relevant data files.

**Demographic and Other Related Variables**

The analysis of NHANES laboratory data must be conducted using the appropriate survey design and demographic variables. The NHANES August 2021-August 2023 Demographics File contains demographic data, health indicators, and other related information collected during household interviews as well as the sample design variables. The recommended procedure for variance estimation requires use of stratum and PSU variables (SDDMVSTRA and SDMVPSU, respectively) in the demographic data file.

The Fasting Questionnaire File includes auxiliary information, such as fasting status, length of fast and the time of venipuncture.

This laboratory data file can be linked to the other NHANES data files using the unique survey participant identifier (i.e., SEQN).

**Detection Limits**

The detection limits were constant for all of the analytes in the data set. Two variables are provided for each of these analytes. The variable name ending "LC" (ex., LBXIHGLC) indicates whether the result was below the limit of detection: the value "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 prefixed LBX (ex., LBXIHG) provides the analytic result for that analyte. For analytes with analytic results below the lower limit of detection (ex., LBXIHGLC=1), an imputed fill value was placed in the analyte results field. This value is the lower limit of detection divided by the square root of 2 (LLOD/sqrt[2]).

The lower limit of detection (LLOD, in µg/L) for Inorganic, Ethyl and Methyl Mercury:

| Variable Name | Analyte Description | LLOD |
|---|---|---|
| LBXIHG | Mercury, inorganic | 0.21 |
| LBXBGE | Mercury, ethyl | 0.064 |
| LBXBGM | Mercury, methyl | 0.26 |

## References

- 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.
- Caudill, S.P., Schleicher, R.L., Pirkle, J.L. Multi-rule quality control for the age-related eye disease study. Statist. Med. (2008) 27(20):4094-40106.
- 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.
- Westgard J.O., Barry P.L., Hunt M.R., Groth T. A multi-rule Shewhart chart for quality control in clinical chemistry. Clin Chem. 1981 Mar; 27(3):493-501.

# Codebook and Frequencies

## SEQN - Respondent sequence number

| | |
|---|---|
| **Variable Name:** | SEQN |
| **SAS Label:** | Respondent sequence number |
| **English Text:** | Respondent sequence number. |
| **Target:** | Both males and females 1 YEARS - 150 YEARS |

# WTPH2YR - Phlebotomy 2 Year Weight

**Variable Name:** WTPH2YR

**SAS Label:** Phlebotomy 2 Year Weight

**English Text:** Phlebotomy 2 Year Weight

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 4391.8220579 to 253478.77765 | Range of Values | 7626 | 7626 | |
| 0 | No blood sample provided | 1101 | 8727 | |
| . | Missing | 0 | 8727 | |

# LBXIHG - Mercury, inorganic (ug/L)

**Variable Name:** LBXIHG

**SAS Label:** Mercury, inorganic (ug/L)

**English Text:** Inorganic mercury, blood (ug/L)

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 0.15 to 17.14 | Range of Values | 7567 | 7567 | |
| . | Missing | 1160 | 8727 | |

# LBDIHGSI - Mercury, inorganic (nmol/L)

**Variable Name:** LBDIHGSI

**SAS Label:** Mercury, inorganic (nmol/L)

**English Text:** Mercury, inorganic (nmol/L)

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 0.75 to 85.53 | Range of Values | 7567 | 7567 | |
| . | Missing | 1160 | 8727 | |

# LBDIHGLC - Mercury, inorganic comment code

**Variable Name:** LBDIHGLC

**SAS Label:** Mercury, inorganic comment code

**English Text:** Mercury, inorganic comment code

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 0 | At or above the detection limit | 942 | 942 | |
| 1 | Below lower detection limit | 6625 | 7567 | |
| . | Missing | 1160 | 8727 | |

# LBXBGE - Mercury, ethyl (ug/L)

**Variable Name:** LBXBGE

**SAS Label:** Mercury, ethyl (ug/L)

**English Text:** Mercury, ethyl (ug/L)

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 0.05 to 0.25 | Range of Values | 7567 | 7567 | |
| . | Missing | 1160 | 8727 | |

# LBDBGESI - Mercury, ethyl (nmol/L)

**Variable Name:** LBDBGESI

**SAS Label:** Mercury, ethyl (nmol/L)

**English Text:** Mercury, ethyl (nmol/L)

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 0.25 to 1.25 | Range of Values | 7567 | 7567 | |
| . | Missing | 1160 | 8727 | |

# LBDBGELC - Mercury, ethyl comment code

**Variable Name:** LBDBGELC

**SAS Label:** Mercury, ethyl comment code

**English Text:** Mercury, ethyl comment code

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 0 | At or above the detection limit | 10 | 10 | |
| 1 | Below lower detection limit | 7557 | 7567 | |
| . | Missing | 1160 | 8727 | |

# LBXBGM - Mercury, methyl (ug/L)

**Variable Name:** LBXBGM

**SAS Label:** Mercury, methyl (ug/L)

**English Text:** Mercury, methyl (ug/L)

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 0.18 to 36.1 | Range of Values | 7567 | 7567 | |
| . | Missing | 1160 | 8727 | |

# LBDBGMSI - Mercury, methyl (nmol/L)

**Variable Name:** LBDBGMSI

**SAS Label:** Mercury, methyl (nmol/L)

**English Text:** Mercury, methyl (nmol/L)

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 0.9 to 180.14 | Range of Values | 7567 | 7567 | |
| . | Missing | 1160 | 8727 | |

# LBDBGMLC - Mercury, methyl comment code

**Variable Name:** LBDBGMLC

**SAS Label:** Mercury, methyl comment code

**English Text:** Mercury, methyl comment code

**Target:** Both males and females 1 YEARS - 150 YEARS

| Code or Value | Value Description | Count | Cumulative | Skip to Item |
|---|---|---|---|---|
| 0 | At or above the detection limit | 4324 | 4324 | |
| 1 | Below lower detection limit | 3243 | 7567 | |
| . | Missing | 1160 | 8727 | |