National Health and Nutrition Examination Survey

2017-March 2020 Data Documentation, Codebook, and Frequencies

Inorganic, Ethyl and Methyl - Blood (P_IHGEM)

Data File: P_IHGEM.xpt

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Component Description

The NHANES program suspended field operations in March 2020 due to the coronavirus disease 2019 (COVID-19) pandemic. As a result, data collection for the NHANES 2019-2020 cycle was not completed and the collected data are not nationally representative. Therefore, data collected from 2019 to March 2020 were combined with data from the NHANES 2017-2018 cycle to form a nationally representative sample of NHANES 2017-March 2020 pre-pandemic data. These data are available to the public. Please refer to the Analytic Notes section for more details on the use of the data.

Inorganic, Ethyl, and Methyl Mercury

Mercury is widespread in the environment and found in its elemental form, inorganic forms such as mercurous and mercuric, and various organic forms such as methyl mercury, ethyl mercury, phenyl mercury, and others. Exposure to inorganic mercury usually occurs by ingestion. The most significant effect is on the kidneys, where mercury accumulates, leading to tubular necrosis. Methyl mercury is more toxic than inorganic mercury. The effects of methyl mercury include changes in vision, sensory disturbances in the arms and legs, cognitive disturbances, dermatitis, and muscle wasting. Methyl mercury readily crosses the blood-brain barrier due to its lipid solubility and accumulates in the brain where it is slowly converted to inorganic mercury. Ethyl mercury is another organic form of mercury. Very little is actually known about ethyl mercury metabolism in humans, including whether it has the same potency as a neurotoxin, whether the blood concentration is ever significant, and even whether it crosses the blood-brain barrier.

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. Blood total mercury can be found in P_PBCD.

Eligible Sample

Examined participants aged 1 year and older in the NHANES 2017-March 2020 pre-pandemic sample 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. Species-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.

Laboratory Method Files

Mercury: Inorganic, Ethyl, and Methyl - Blood (June 2020)

Mercury: Inorganic, Ethyl, and Methyl - Blood (November 2021)

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 2017-2018 and 2019-2020 NHANES Laboratory Procedures Manuals (LPMs). 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 Act mandates. Detailed QA/QC instructions are discussed in the NHANES LPMs.

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

The COVID-19 pandemic required suspension of NHANES 2019-2020 field operations in March 2020 after data were collected in 18 of the 30 survey locations in the 2019-2020 sample. Data collection was cancelled for the remaining 12 locations. Because the collected data from 18 locations were not nationally representative, these data were combined with data from the previous cycle (2017-2018) to create a 2017-March 2020 pre-pandemic data file. A special weighting process was applied to the 2017-March 2020 pre-pandemic data file. The resulting sample weights in the demographic data file should be used to calculate estimates from the combined cycles. These sample weights are not appropriate for independent analyses of the 2019-2020 data and will not yield nationally representative results for either the 2017-2018 data alone or the 2019-March 2020 data alone. Please refer to the NHANES website for additional information for the NHANES 2017-March 2020 pre-pandemic data, and for the previous 2017-2018 public use data file with specific weights for that 2-year cycle.

Refer to the 2017-2018 and 2019-2020 Laboratory Data Overview documents for general information on NHANES laboratory data.

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. For example, in 2017-March 2020 approximately 76% of children aged 1-17 years who were examined in the MEC provided a blood specimen through phlebotomy, while 95% of examined adults age 18 and older provided a blood specimen. 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.

Demographic and Other Related Variables

The analysis of NHANES laboratory data must be conducted using the appropriate survey design and demographic variables. The NHANES 2017 – March 2020 Pre-Pandemic 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

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 33.95	Range of Values	12029	12029	
.	Missing	1743	13772	

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 169.41	Range of Values	12029	12029	
.	Missing	1743	13772	

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	2352	2352	
1	Below lower detection limit	9677	12029	
.	Missing	1743	13772	

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 1.01	Range of Values	12029	12029	
.	Missing	1743	13772	

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 5.04	Range of Values	12029	12029	
.	Missing	1743	13772	

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	79	79	
1	Below lower detection limit	11950	12029	
.	Missing	1743	13772	

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 55.9	Range of Values	12029	12029	
.	Missing	1743	13772	

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 278.94	Range of Values	12029	12029	
.	Missing	1743	13772	

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	6760	6760	
1	Below lower detection limit	5269	12029	
.	Missing	1743	13772	