National Health and Nutrition Examination Survey

2017-March 2020 Data Documentation, Codebook, and Frequencies

Lead, Cadmium, Total Mercury, Selenium, & Manganese - Blood (P_PBCD)

Data File: P_PBCD.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.

Lead

Lead is a known environmental toxin that has been shown to affect deleteriously the nervous, hematopoietic, endocrine, renal, and reproductive systems. In young children, lead exposure is a particular hazard because children more readily absorb lead than adults, and children's developing nervous systems also make them more susceptible to the effects of lead. The primary sources of exposure for children are lead-laden paint chips and dust as a result of deteriorating lead-based paint. The risk for lead exposure is disproportionately higher for children who are poor, non-Hispanic black, living in large metropolitan areas, or living in older housing. Among adults, the most common high exposure sources are occupational. Blood lead levels measured in previous NHANES cycles have been the cornerstone of lead exposure surveillance in the U.S. The data have been used to document the burden and dramatic decline of elevated blood lead levels, to promote the reduction of lead use, and to help to redefine national lead poisoning prevention guidelines, standards, and abatement activities.

Cadmium

Blood cadmium reflects both recent and cumulative exposures. Cadmium is absorbed via inhalation and ingestion. Occupational exposure is the most common cause of elevated cadmium levels. Inhalation of cigarette smoke is a predominant source of exposure in smokers whose blood cadmium levels have been observed to be about twice as high compared to nonsmokers. For nonsmokers who are not exposed to cadmium in the workplace, ingestion through food is the largest source of exposure. With chronic exposure, cadmium accumulates in the liver and kidneys where it is bound to metallothionein, an inducible metal binding protein. The kidney is a critical target and shows the earliest sign of cadmium toxicity. Cadmium can produce lung, pituitary gland and kidney tumors in animals and has been associated with lung cancer in humans in occupational epidemiologic studies. Both International Agency for Research on Cancer (IARC) and National Toxicology Program (NTP) consider cadmium a human carcinogen.

Manganese

The greatest demand for manganese is for the production of iron and steel. In addition, it is a key component of low-cost stainless steel and certain aluminum alloys. At low concentrations, it is used to decolorize glass, while at higher concentrations; it is used to make violet-colored glass. Manganese dioxide, besides being a useful pigment, is a catalyst and a component of certain dry cell batteries. Potassium permanganate is a potent oxidizer and disinfectant. Manganese (in the form of manganese ions) is an essential trace nutrient in all known forms of life. On the other hand, excess manganese is toxic.

Total 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 mercury levels will be assessed in two subpopulations particularly vulnerable to the health effects from mercury exposure: children 1-5 years old and women of childbearing age. Blood measures of total and inorganic mercury will be important for evaluation of exposure from exposure to mercury in interior latex paints.

Selenium

Selenium salts are toxic in large amounts, but trace amounts are necessary for cellular function in many organisms, including all animals. Selenium is a component of the antioxidant enzymes glutathione peroxidase and thioredoxin reductase (which indirectly reduce certain oxidized molecules in animals and some plants). It is also found in three deiodinase enzymes, which convert one thyroid hormone to another. Selenium requirements in plants differ by species, with some plants requiring relatively large amounts, and others apparently requiring none.

Eligible Sample

Examined participants aged 1 year and older in the NHANES 2017-March 2020 pre-pandemic sample were eligible. Due to disclosure concern, blood lead data from participants aged 1-5 years may only be accessed through the NCHS Research Data Center. Blood lead data from participants aged 6 years and older, and blood cadmium, manganese, total mercury, and selenium data from all examined participants 1 years and older are included in this dataset. See Analytic Notes for additional information on blood lead data from participants aged 1-5 years.

Description of Laboratory Methodology

This method directly measures lead (Pb), cadmium (Cd), total mercury (Hg), manganese (Mn), and selenium (Se) content of whole blood specimens using mass spectrometry after a simple dilution sample preparation step.

During the sample dilution step, a small volume of whole blood is extracted from a larger whole blood patient specimen after the entire specimen is mixed (vortexed) to create a uniform distribution of cellular components. This mixing step is important because some metals (e.g., Pb) are known to be associated mostly with the red blood cells in the specimen and a uniform distribution of this cellular material must be produced before a small volume extracted from the larger specimen will accurately reflect the average metal concentration of all fractions of the larger specimen. Coagulation is the process in which blood forms solid clots from its cellular components. If steps are not taken to prevent this process from occurring, i.e., addition of anti-coagulant reagents such as EDTA in the blood collection tube prior to blood collection, blood will immediately begin to form clots once leaving the body and entering the tube. These clots prevent the uniform distribution of cellular material in the blood specimen even after rigorous mixing, making a representative sub-sample of the larger specimen unattainable. It is important that prior to or during sample preparation the analyst identify any sample having clots or micro-clots (small clots). Clotted samples are not analyzed by this method due to the inhomogeneity concerns (i.e., all results for the sample are processed as “not reportable”).

Liquid samples are introduced into the mass spectrometer through the inductively coupled plasma (ICP) ionization source. The liquid diluted blood sample is forced through a nebulizer with argon gas, which converts the bulk liquid into an aerosol of small droplets. The smaller droplets in the aerosol are selectively passed through the spray chamber by a flowing argon stream into the 6000-8000K plasma of the ICP. The high energy of the plasma results in the ionization of the atoms of lead, cadmium, mercury, manganese, and selenium from the droplets from the sample. The ions enter the mass spectrometer through an interface that separates the atmospheric pressure, ~760 torr, of the ICP from the vacuum region, ~10^{-5} torr, within the mass spectrometer. After the interface, the ions pass through a focusing region, then the first quadrupole mass filter (Q1), the collision-reaction cell (or octopole reaction system, ORS), a second quadrupole mass filter (Q2), and finally are selectively counted in rapid sequence of mass-to-charge ratios at the detector.

Electrical signals associated with each mass-to-charge ratio monitored are summed by a computer, and the magnitude of the signals detected while aspirating an unknown sample is correlated to an elemental concentration through comparison of the blank-subtracted analyte / internal standard signal ratio of the unknown sample with the signal ratio obtained when aspirating calibrators. This method was originally based on the method by Jones (Jones, et al., 2017).

Refer to the Laboratory Method Files section for a detailed description of the laboratory methods used. There was a change to the method between the 2017-2018 and the 2019-March 2020 cycles.

Laboratory Method Files

Cadmium, Lead, Manganese, Mercury, and Selenium Lab Procedure Manual (June 2020)

Cadmium, Lead, Manganese, Mercury, and Selenium Lab Procedure Manual (November 2021)

Laboratory Quality Assurance and Monitoring

Whole blood specimens were processed, stored, and shipped to the 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 Amendments 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 Environmental Health 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.

Five additional variables were created for this data file. The variables were created using the following formulas:

LBDBCDSI: The analyte cadmium value in µg/L (LBXBCD) was converted to nmol/L (LBDBCDSI) by multiplying LBXBCD by 8.897 (Round 3 decimal points).

LBDBPBSI: The analyte lead value in µg/dL (LBXBPB) was converted to µmol/L (LBDBPBSI) by multiplying LBXBPB by 0.0483 (Round 3 decimal points).

LBDBMNSI: The analyte manganese value in µg/L (LBXBMN) was converted to nmol/L (LBDBMNSI) by multiplying LBXBMN by 18.202 (Round 2 decimal points).

LBDBSESI: The analyte selenium value in µg/L (LBXBSE) was converted to µmol/L (LBDBSESI) by multiplying LBXBSE by 0.0127 (Round 2 decimal points).

LBDTHGSI: The analyte mercury value in µg/L (LBXTHG) was converted to nmol/L (LBDTHGSI) by multiplying LBXTHG by 4.99 (Round 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 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 (SDMVSTRA 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 change in methods between the 2017-2018 and 2019-March 2020 cycles resulted in different lower detection limits between the data obtained in the 2019-March 2020 and those in the 2017-2018 survey cycle. In order to make the merged dataset compatible the higher detection limit of the two methods for each analyte was used for both cycles. Two variables are provided for each of these analytes. The variable name ending in “LC” (ex., LBDBCDLC) 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., LBXBCD) provides the analytic result for the analyte. For analytes with analytic results below the lower limit of detection (ex. LBDBCDLC=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 cadmium, manganese, total mercury and selenium, and (LLOD, in ug/dL) for lead in the present dataset are:

Variable Name	Analyte Description	LLOD
LBXBCD	Cadmium, blood	0.100
LBXBPB	Lead, blood	0.070
LBXMN	Manganese, blood	0.99
LBXTHG	Mercury, total, blood	0.28
LBXBSE	Selenium, blood	24.48

Data Access

Blood Lead data for youth aged 1-5 years are included in file “Lead – Blood - Youth (P_PBY_R)”, and available through the NCHS Research Data Center.

References

- Jones, D.R., et al., Analysis of whole human blood for Pb, Cd, Hg, Se, and Mn by ICP-DRC-MS for biomonitoring and acute exposures. Talanta, 2017. 162: p. 114-122.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.
- 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.
- 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

LBXBPB - Blood lead (ug/dL)

Variable Name: LBXBPB

SAS Label: Blood lead (ug/dL)

English Text: Blood lead (ug/dL)

Target: Both males and females 6 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.049 to 42.48	Range of Values	11107	11107	
.	Missing	2665	13772	

LBDBPBSI - Blood lead (umol/L)

Variable Name: LBDBPBSI

SAS Label: Blood lead (umol/L)

English Text: Blood lead (umol/L)

Target: Both males and females 6 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.002 to 2.052	Range of Values	11107	11107	
.	Missing	2665	13772	

LBDBPBLC - Blood lead comment code

Variable Name: LBDBPBLC

SAS Label: Blood lead comment code

English Text: Blood lead comment code

Target: Both males and females 6 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0	At or above the detection limit	11103	11103	
1	Below lower detection limit	4	11107	
.	Missing	2665	13772	

LBXBCD - Blood cadmium (ug/L)

Variable Name: LBXBCD

SAS Label: Blood cadmium (ug/L)

English Text: Blood cadmium (ug/L)

Target: Both males and females 1 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.071 to 13.03	Range of Values	12102	12102	
.	Missing	1670	13772	

LBDBCDSI - Blood cadmium (nmol/L)

Variable Name: LBDBCDSI

SAS Label: Blood cadmium (nmol/L)

English Text: Blood cadmium (nmol/L)

Target: Both males and females 1 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.632 to 115.928	Range of Values	12102	12102	
.	Missing	1670	13772	

LBDBCDLC - Blood cadmium comment code

Variable Name: LBDBCDLC

SAS Label: Blood cadmium comment code

English Text: Blood cadmium 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	9720	9720	
1	Below lower detection limit	2382	12102	
.	Missing	1670	13772	

LBXTHG - Blood mercury, total (ug/L)

Variable Name: LBXTHG

SAS Label: Blood mercury, total (ug/L)

English Text: Blood mercury, total (ug/L)

Target: Both males and females 1 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.2 to 63.64	Range of Values	12102	12102	
.	Missing	1670	13772	

LBDTHGSI - Blood mercury, total (nmol/L)

Variable Name: LBDTHGSI

SAS Label: Blood mercury, total (nmol/L)

English Text: Blood mercury, total (nmol/L)

Target: Both males and females 1 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1 to 317.56	Range of Values	12102	12102	
.	Missing	1670	13772	

LBDTHGLC - Blood mercury, total comment code

Variable Name: LBDTHGLC

SAS Label: Blood mercury, total comment code

English Text: Blood mercury, total 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	8296	8296	
1	Below lower detection limit	3806	12102	
.	Missing	1670	13772	

LBXBSE - Blood selenium (ug/L)

Variable Name: LBXBSE

SAS Label: Blood selenium (ug/L)

English Text: Blood selenium(ug/L)

Target: Both males and females 1 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
74.8 to 562.23	Range of Values	12102	12102	
.	Missing	1670	13772	

LBDBSESI - Blood selenium (umol/L)

Variable Name: LBDBSESI

SAS Label: Blood selenium (umol/L)

English Text: Blood selenium (umol/L)

Target: Both males and females 1 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.95 to 7.14	Range of Values	12102	12102	
.	Missing	1670	13772	

LBDBSELC - Blood selenium comment code

Variable Name: LBDBSELC

SAS Label: Blood selenium comment code

English Text: Blood selenium 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	12102	12102	
1	Below lower detection limit	0	12102	
.	Missing	1670	13772	

LBXBMN - Blood manganese (ug/L)

Variable Name: LBXBMN

SAS Label: Blood manganese (ug/L)

English Text: Blood manganese (ug/L)

Target: Both males and females 1 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1.57 to 53.69	Range of Values	12102	12102	
.	Missing	1670	13772	

LBDBMNSI - Blood manganese (nmol/L)

Variable Name: LBDBMNSI

SAS Label: Blood manganese (nmol/L)

English Text: Blood manganese (nmol/L)

Target: Both males and females 1 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
28.58 to 977.27	Range of Values	12102	12102	
.	Missing	1670	13772	

LBDBMNLC - Blood manganese comment code

Variable Name: LBDBMNLC

SAS Label: Blood manganese comment code

English Text: Blood manganese 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	12102	12102	
1	Below lower detection limit	0	12102	
.	Missing	1670	13772	