National Health and Nutrition Examination Survey

2017-March 2020 Data Documentation, Codebook, and Frequencies

Cholesterol - Low-Density Lipoproteins (LDL) & Triglycerides (P_TRIGLY)

Data File: P_TRIGLY.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.

Heart disease is the leading cause of death in the United States (Murphy, et. al., 2018). Blood lipid levels are fundamental measures included in NHANES that can be used for cardiovascular risk assessment. The goals of NHANES blood lipid measurements include: 1) monitoring the prevalence and trends in major cardiovascular conditions and overall risk factors in the U.S.; 2) evaluating prevention and treatment programs targeting cardiovascular disease in the U.S.; and 3) monitoring the status of hyperlipidemia.

In 2018, new Blood Cholesterol Guidelines were released, by the American College of Cardiology and American Heart Association Task Force on Clinical Practice Guidelines, which aim to reduce the risk of atherosclerotic cardiovascular disease through cholesterol management (Grundy, et. al., 2018). The blood lipids measurements in NHANES include total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoproteins cholesterol (LDL-C), and triglycerides. The present file provides data on LDL-C and triglycerides. Data on total cholesterol are provided in the Cholesterol - Total (P_TCHOL) file, and HDL-C data are provided in Cholesterol - High - Density Lipoprotein (P_HDL).

Eligible Sample

All examined participants 12 years and older, in the NHANES 2017-March 2020 pre-pandemic sample, were eligible.

Description of Laboratory Methodology

This method to measure triglycerides is based on the work by Wahlefeld (Roche, 2014) using a lipoprotein lipase from microorganisms for the rapid and complete hydrolysis of triglycerides to glycerol followed by oxidation to dihydroxyacetone phosphate and hydrogen peroxide. The hydrogen peroxide produced then reacts with 4-aminophenazone and 4-chlorophenol under the catalytic action of peroxidase to form a red dyestuff (Trinder endpoint reaction). The color intensity of the red dyestuff formed is directly proportional to the triglyceride concentration and can be measured photometrically.

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

Serum LDL-C levels were calculated from directly measured values of total cholesterol, triglycerides, and HDL-C. Please see below the Data Processing and Editing section for more details. For laboratory methods used for total cholesterol and HDL-C, please refer to the accompanying documentation: P_TCHOL and P_HDL.

Laboratory Method Files

Triglycerides (December 2020)

Triglycerides (October 2021)

Laboratory Quality Assurance and Monitoring

Serum samples were processed, stored, and shipped to University of Minnesota, Minneapolis, MN for analysis.

Detailed instructions on specimen collection and processing are discussed in the NHANES 2017-2018 and 2019-2020 Laboratory Procedures Manuals (LPMs). Vials are stored under appropriate frozen (–30°C) conditions until they are shipped to University of Minnesota for testing.

The NHANES quality assurance and quality control protocols (QA/QC) 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 during “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 CDC and 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.

Data Processing and Editing

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

Seven derived variables were created in this data file: one for triglycerides, and six for LDL-C. The formulas used to derive these variables are provided below.

Triglycerides - International System of Units (LBDTRSI)

The triglyceride values in mg/dL **(LBXTR)** were converted to mmol/L **(LBDTRSI)** by multiplying by 0.01129.

Calculated LDL-C LEVELS

Serum LDL-C levels were derived on study participants examined in the morning session only. LDL-C is calculated from directly measured values of total cholesterol (LBXTC), triglycerides (LBXTR), and HDL-C (LBDHDD). Beginning with the 2017-2018 data, three equations are available for calculating LDL-C: the Friedewald equation; the Martin-Hopkins equation; and the NIH Equation 2.

The Friedewald equation has been the standard equation used for the calculation of LDL-C for clinical use for decades. The Friedewald equation estimates LDL-C concentration using directly measured total cholesterol, triglycerides, and HDL-C results, and a fixed factor of 5 to estimate the triglyceride to very low-density lipoprotein cholesterol (VLDL-C) ratio and is based on a direct LDL-C by beta quantification reference method from 448 samples (Friedewald, 1972). NHANES has used the Friedewald equation to calculate LDL-C since the release of the Third National Health and Nutrition Examination Survey (NHANES III) (1988-1994 data) in 1996. Studies over the years have shown that the equation underestimates LDL-C at lower levels, specifically those with LDL-C levels less than 70 mg/dL and/or high triglyceride levels, potentially leading to an undertreatment with lipid-lowering medications (Sathiyakumar, et. al., 2020). The Friedewald equation is not valid for triglyceride results greater than 400 mg/dL.

The Martin-Hopkins equation for calculating LDL-C was recommended in the 2018 Blood Cholesterol Guidelines, specifically those with LDL-C levels less than 70 mg/dL. It is based on a Vertical Auto Profile direct ultracentrifugation method from 1.35 million patients (Martin, et. al., 2013). The Martin-Hopkins equation applies an adjustable factor on an individual participant's median triglyceride to VLDL-C ratio based on non-HDL cholesterol (NONHDL, calculated by subtracting HDL-C from total cholesterol [NON-HDL=LBXTC-LBDHDD]) and triglyceride concentrations (Martin, et. al., 2013). To establish the adjustable factors 10, 20, 30, 60, 90, 120, 150, 180, 200, 300, 360, 400, 720, 800, 1000, and 2000 cell two-dimensional strata tables were developed (Martin, et. al., 2013). NHANES employs the 360-cell strata table to generate adjustable factors for the triglyceride to VLDL-C ratio for calculating LDL-C. Like the Friedewald equation, the Martin-Hopkins equation is not valid for triglyceride results greater than 400 mg/dL.

In January 2020, Sampson, et. al released the NIH Equation 2. Like the Friedewald equation, it is based on a direct LDL-C by beta quantification reference method, though from a much larger sample consisting of 8,656 patients (18,715 lipid samples) (Sampson, et. al., 2020). Of the three equations for calculating LDL-C, the NIH Equation 2 has the best accuracy at triglyceride levels greater than or equal to 400 mg/dL. NIH Equation 2 has not been as scrutinized as the Friedewald and Martin-Hopkins equations and requires additional external validation, as it was released in 2020. However, it has been implemented by one major US laboratory with an expansive nationwide network. The NIH Equation 2 is not valid for triglyceride results greater than 800 mg/dL.

All three equations are being released in this dataset. All calculated LDL-C data were converted into International System of Units (SI units) for each equation.

Friedewald Equation (LBDLDL):

LBDLDL [LDL-C (Friedewald)] = LBXTC – LBDHDD – LBXTR[a]/5

[a]Where triglyceride levels are less than 400 mg/dL.

Friedewald Equation – SI units (LBDLDLSI)

The LDL-C (Friedewald) in mg/dL **(LBDLDL)** was converted to mmol/L **(LBDLDLSI)** by multiplying by 0.02586.

LBDLDLSI=.02586*LBDLDL

Martin-Hopkins Equation (LBDLDLM):

LBDLDLM [LDL-C (Martin-Hopkins)] = LBXTC-LBDHDD-LBXTR[a]/Adjustable Factor[b]

[a]Where triglyceride levels are less than 400 mg/dL

[b]Where the Adjustable factor, an estimate of the trigylceride to VLDL cholesterol ratio, depends upon the values of non-HDL-C and triglycerides.

Martin-Hopkins Equation - SI units (LBDLDMSI)

The LDL-C (Martin-Hopkins) in mg/dL **(LBDLDLM)** was converted to mmol/L **(LBDLDMSI)** by multiplying by 0.02586.

LBDLDMSI=.02586*LBDLDLM

NIH Equation 2 (LBDLDLN):

LBDLDLN [LDL-C (NIH)] =

LBXTC/0.948–LBDHDD/0.971-(LBXTR/8.56 + LBXTR[c] * NONHDL/2140–LBXTR^2/16100)–9.44

[c]Where triglyceride levels are less than 800 mg/dL.

$$LDL-C = \frac{TC}{.948} - \frac{HDL-C}{.971} - \left(\frac{TG}{8.56} + \frac{[TG * non-HDL]}{2140} - \frac{TG^2}{16100}\right) - 9.44$$

NIH Equation 2 - SI units (LBDLDNSI)

The LDL-C (NIH Equation 2) in mg/dL **(LBDLDLN)** was converted to mmol/L **(LBDLDNSI)** by multiplying by 0.02586.

LBDLDLNSI=.02586*LBDLDLN

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 this 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.

Total Cholesterol and Low Density Lipoprotein Cholesterol Values from the NHANES 2017–March 2020 Pre-Pandemic Sample

The laboratory that performed total cholesterol assays for NHANES samples from 2017 to March 2020 participated in the CDC Lipid Standardization Program (LSP) that monitors the quality of laboratory results over time. The LSP requires comparing assay results to a CDC control pool to assess lab result quality. For total cholesterol measures in 2019, the mean bias reported by the laboratory exceeded the criterion of 3% mean allowable bias (the maximum quarterly bias was -4.7%). However, evaluation using NHANES data from 2017-March 2020 only indicated minimal differences between prevalence estimates of high total cholesterol based on the original total cholesterol values and those based on values adjusted to compensate for the downward bias (please see documentation for Cholesterol – Total [P_TCHOL] for additional details).

Because total cholesterol values are used to calculate low density lipoprotein cholesterol (LDL-C) values, NHANES also evaluated whether the downward bias in total cholesterol values meaningfully affected LDL-C values. Using values for total cholesterol adjusted to account for downward bias, LDL-C was recalculated using the Friedewald equation. The results indicated minimum differences in 2017-March 2020 LDL-C values with total cholesterol adjustment: mean LDL-C using adjusted values of total cholesterol were 0.5% lower than mean calculated with original values of total cholesterol. Therefore, values of LDL-C calculated using unadjusted laboratory values for total cholesterol for 2017-March 2020 were released in the dataset.

Subsample Weights

Triglycerides were measured in a fasting subsample of participants 12 years and older. Special sample weights 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.

Participants included in the fasting subsample but did not provide a blood specimen (n=346) have an assigned sample weight value of “0” in their records. In addition, participants whom provided a blood specimen but did not meet the 8 to less than 24 hours fasting criteria (n=268) have the sample weight value assigned as “0” (WTSAFPRP =0) as well. Six of these 268 participants did not provide enough volume to have their triglycerides tested. Triglyceride measurements for the other 262 participants are included in the dataset. However, to include these data in the analysis, a reweighting is required. There are another 88 participants in the fasting subsample that did not provide enough blood; therefore, they did not have triglycerides measured. However, these participants have data in at least one other fasting subsample tests (e.g., plasma fasting glucose). Therefore, they have a sample weight larger than “0,” regardless of missing their triglyceride test results.

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 weight variables. The recommended procedure for variance estimation requires use of stratum and PSU variables (SDMVSTRA and SDMVPSU, respectively) in the demographic data file.

The 2017-March 2020 Pre-pandemic Fasting Questionnaire File includes auxiliary information, such as fasting status, length of fast, and the time of venipuncture.

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

Triglycerides (LBXTR)

Serum levels were measured for participants that were examined in the morning session only. The distribution of serum triglycerides should only be estimated on participants aged 12 years and over who fasted at least 8 hours or more, but less than 24 hours. PHAFSTHR (total length of “food fast”, hours) and PHAFSTMN (Total length of “food fast”, minutes) can be found in the Fasting Questionnaire File.

The P_TRIGLY data file contains laboratory test results for triglycerides (LBXTR) using the reference analytic method. However, the NHANES Standard Biochemistry Profile (P_BIOPRO) also includes measurements of triglycerides (LBXSTR). The appropriate variable to use for the most accurate data analysis is **LBXTR** from the P_TRIGLY data file.

Detection Limits

The detection limits were constant for this analyte in the data set. The variable prefixed LBX (ex., LBXTR) provides the analytic result for that analyte.

The lower limit of detection (LLOD, in mg/dL) for triglycerides:

Variable Name	SAS Label	LLOD
LBXTR	Serum Triglycerides	9

References

- Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972;18(6):499–502.
- Grundy SM, Stone NJ, Bailey AL, Beam C, Birtcher KK, Blumenthal RS, Braun LT, Braun LT, de Ferranti S, Faiella-Tommasino J, Forman DE, Goldberg R, Heidenreich PA, Hlatky MA, Jones DW, Lloyd-Jones D, Lopez-Pajares N, Ndumele CE, Orringer CE, Peralta CA, Saseen JJ, Smith Jr SC, Sperling L, Virani SS, Yeboah J, 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ ADA/AGS/APhA/ASPC/NLA/PCNA Guideline on the Management of Blood Cholesterol: Executive Summary, Journal of the American College of Cardiology (2018), doi: https://doi.org/10.1016/j.jacc.2018.11.002.
- Martin, S. S., Blaha, M. J., Elshazly, M. B., Toth, P. P., Kwiterovich, P. O., Blumenthal, R. S., & Jones, S. R. (2013). Comparison of a novel method vs the Friedewald equation for estimating low-density lipoprotein cholesterol levels from the standard lipid profile. *JAMA*, *310*(19), 2061–2068. https://doi.org/10.1001/jama.2013.280532.
- Murphy SL, Xu JQ, Kochanek KD, Arias, E. Mortality in the United States, 2017. NCHS Data Brief, no 328. Hyattsville, MD: National Center for Health Statistics. 2018. https://www.cdc.gov/nchs/data/databriefs/db328-h.pdf Accessed May, 2019.
- Roche Trig/GB reagent package insert. Version 2014-06, V8.0. Roche Diagnostics Inc., 9115 Hague Road Indianapolis, IN 46250-0457.
- Sampson M. Ling C, Qian Sun, Harb R, et al. A New Equation for Calculation of Low-Density Lipoprotein Cholesterol in Patients with Normolipidemia and/or Hypertriglyceridemia. JAMA Cardiol. February 26, 2020. E1-E8.
- Sathiyakumar, V., Blumenthal, RS, Elshazly, MB. New Information on Accuracy of LDL-C Estimation, 2020. American College of Cardiology. https://www.acc.org/latest-in-cardiology/articles/2020/03/19/16/00/new-information-on-accuracy-of-ldl-c-estimation. Accessed December 2020
- 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) 27:493-501.

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 12 YEARS - 150 YEARS

WTSAFPRP - Fasting Subsample Weight

Variable Name: WTSAFPRP

SAS Label: Fasting Subsample Weight

English Text: Fasting Subsample Weight

Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
4808.069916 to 741259.18875	Range of Values	4476	4476	
0	No Lab Result	614	5090	
.	Missing	0	5090	

LBXTR - Triglyceride (mg/dL)

Variable Name: LBXTR

SAS Label: Triglyceride (mg/dL)

English Text: Triglyceride (mg/dL)

Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
10 to 2684	Range of Values	4650	4650	
.	Missing	440	5090	

LBDTRSI - Triglyceride (mmol/L)

Variable Name: LBDTRSI

SAS Label: Triglyceride (mmol/L)

English Text: Triglyceride (mmol/L)

Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.113 to 30.302	Range of Values	4650	4650	
.	Missing	440	5090	

LBDLDL - LDL-Cholesterol, Friedewald (mg/dL)

Variable Name: LBDLDL

SAS Label: LDL-Cholesterol, Friedewald (mg/dL)

English Text: LDL-Cholesterol, Friedewald equation (mg/dL). LBDLDL = (LBXTC-(LBDHDD + LBXTR/5), round to 0 decimal places) for LBXTR less than 400 mg/dL, and missing for LBXTR greater than 400 mg/dL. LBDHDD from public release file P_HDL

Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
7 to 357	Range of Values	4617	4617	
.	Missing	473	5090	

LBDLDLSI - LDL-Cholesterol, Friedewald (mmol/L)

Variable Name: LBDLDLSI

SAS Label: LDL-Cholesterol, Friedewald (mmol/L)

English Text: LDL-Cholesterol, Friedewald equation (mmol/L)

Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.181 to 9.232	Range of Values	4617	4617	
.	Missing	473	5090	

LBDLDLM - LDL-Cholesterol, Martin-Hopkins (mg/dL)

Variable Name: LBDLDLM

SAS Label: LDL-Cholesterol, Martin-Hopkins (mg/dL)

English Text: LDL-Cholesterol, Martin-Hopkins equation (mg/dL). LBDLDLM = (LBXTC-(LBDHDD + LBXTR/Adjustable Factor), round to 0 decimal places) for LBXTR less than 400 mg/dL, and missing for LBXTR greater than 400 mg/dL. LBDHDD from public release file P_HDL

Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
14 to 358	Range of Values	4617	4617	
.	Missing	473	5090	

LBDLDMSI - LDL-Cholesterol, Martin-Hopkins (mmol/L)

Variable Name: LBDLDMSI

SAS Label: LDL-Cholesterol, Martin-Hopkins (mmol/L)

English Text: LDL-Cholesterol, Martin-Hopkins equation (mmol/L)

Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.362 to 9.258	Range of Values	4617	4617	
.	Missing	473	5090	

LBDLDLN - LDL-Cholesterol, NIH equation 2 (mg/dL)

Variable Name: LBDLDLN

SAS Label: LDL-Cholesterol, NIH equation 2 (mg/dL)

English Text: LBDLDLN = (LBXTC/0.948 – LBDHDD/0.971 – (LBXTR/8.56 + (LBXTR * (LBXTC – LBDHDD))/2140 – LBXTR^2/16100) – 9.44), round 0 decimal places) for LBXTR less than 800 mg/dL, and missing for LBXTR GE 800 mg/dL. ^2 stands for power=2, or squared. LBDHDD from public release file P_HDL

Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
14 to 359	Range of Values	4642	4642	
.	Missing	448	5090	

LBDLDNSI - LDL-Cholesterol, NIH equation 2 (mmol/L)

Variable Name: LBDLDNSI

SAS Label: LDL-Cholesterol, NIH equation 2 (mmol/L)

English Text: LDL-Cholesterol, NIH equation 2 (mmol/L)

Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0.362 to 9.284	Range of Values	4642	4642	
.	Missing	448	5090	