

Laboratory Procedure Manual

Analyte: **Iron Concentration Timed-endpoint Method**

Matrix: **Serum**

Method: **Beckman Synchron**

as performed by: Collaborative Laboratory Services
Ottumwa, Iowa

Contact: Dr. David Witte

February 2008

**Iron in Serum
NHANES 2001-2002**

Public Release Data Set Information

This document details the Lab Protocol for NHANES 2001-2002 data.

A tabular list of the released analytes follows:

Lab Number	Analyte	SAS Label (and SI units)
140fe_b	LBXIRN	Iron, frozen serum ($\mu\text{g/dL}$)
	LBDIRNSI	Iron, frozen serum ($\mu\text{mol/dL}$)

Iron in Serum

NHANES 2001-2002

1. SUMMARY OF TEST PRINCIPLE AND CLINICAL RELEVANCE

The method used to measure the iron concentration is a timed-endpoint method. In the reaction, iron is released from transferrin by acetic acid and is reduced to the ferrous state by hydroxylamine and thioglycolate. The ferrous ion is immediately complexed with the FerroZine Iron Reagent. The system monitors the change in absorbance at 560 nm at a fixed-time interval. This change in absorbance is directly proportional to the concentration of iron in the sample.

Serum iron measurements in conjunction with total iron binding capacity are useful in the diagnosis and treatment of disorders relating to iron intake, absorption, storage, and release mechanisms. Such changes are indicative of a wide range of dysfunctions including anemias, nephrosis, cirrhosis and hepatitis.

2. SAFETY PRECAUTIONS

Consider all plasma or serum specimens potentially positive for infectious agents including HIV and the hepatitis B virus. We recommend the hepatitis B vaccination series for all analysts working with whole blood and/or plasma. Observe universal precautions; wear protective gloves, laboratory coats. Place disposable plastic, glass, and paper (pipette tips, gloves, etc.) that contact plasma and any residual sample material in a biohazard bag and keep these bags in appropriate containers until disposal by maceration chlorination. Wipe down all work surfaces with Sani-Cloth HB, Germicidal Disposable Wipe when work is finished.

Handle acids and bases with extreme care; they are caustic and toxic. Handle organic solvents only in a well-ventilated area or, as required, under a chemical fume hood.

Reagents and solvents used in this study include those listed in Section 6. Material safety data sheets (MSDSs) for these chemicals are readily accessible as hard copies in the lab.

3. COMPUTERIZATION; DATA SYSTEM MANAGEMENT

- A. Microsoft Excel software on a PC and our Laboratory Information Systems (L.I.S.) are used to manage the data. The test is analyzed on a Beckman Synchron LX20. When all ordered tests are completed for each sample, the results are printed out by Beckman Synchron LX20 instrument. The LX20 is interfaced to the Laboratory Information Systems (L.I.S.) with a bi-directional interface. After results have printed at the LX20 printer, the results will go to the L.I.S. Host Interface Workstation to be collated and then certified by qualified analyst.
- B. A statistical evaluation of the runs is accomplished with Microsoft Excel software on a PC. An Adhoc report of the completed runs data is saved to a floppy disk in a comma delimited format (csv) text file. The file is opened and copied to an Excel spreadsheet for evaluation. The Excel spreadsheet results file data are copied to the shipment file and saved as a comma delimited file (csv) and e-mailed to Westat within 21 days of sample receipt.
- C. The Excel files containing all raw data and results are backed up once a week using a CD writer or Zip drive for storage. Files stored on the L.I.S. network are automatically backed up nightly to tape.
- D. Documentation for data system maintenance is contained in printed copies of data records, as well as in "system log" files on the local hard drives used for the archival of data.

Iron in Serum NHANES 2001-2002

4. SPECIMEN COLLECTION, STORAGE, AND HANDLING PROCEDURES; CRITERIA FOR SPECIMEN REJECTION

- A. Interferences:
 - 1. No interference from lipemia or bilirubin <30 mg/dL.
 - 2. No interference from hemolysis.
- B. Serum/plasma should be separated from the red cells within two hours after collection.
- C. Separated serum or plasma should not remain at +15°C to +30°C longer than 8 hours. If assays are not completed within 8 hours, serum or plasma should be stored at +2°C to +8°C. If assays are not completed within 48 hours, or the separated sample is to be stored beyond 48 hours, samples should be frozen at -15°C to -20°C. Frozen samples should be thawed only once. Analyte deterioration may occur in samples that are repeatedly frozen and thawed.
- D. Samples should be drawn in the morning due to diurnal variation.
- E. Iron-dextran administration can cause elevations of iron with this method.
- F. Ingestion of oral contraceptives will elevate iron or TIBC values.
- G. A minimum of 0.6 mL serum is needed for the Multi-Analyte Panel.
- H. Sample volume for individual test is 25 µl added to 210 µl reagent.
- I. Sample is run singly as part of Multi-analyte Biochemistry Panel.
- J. Only plastic or borosilicate glass containers should be used to store samples.

5. PROCEDURES FOR MICROSCOPIC EXAMINATIONS; CRITERIA FOR REJECTION OF INADEQUATELY PREPARED SLIDES

Not applicable for this procedure

6. EQUIPMENT AND INSTRUMENTATION, MATERIALS, REAGENT PREPARATION, CALBRATORS (STANDARDS), AND CONTROLS

- A. Instrumentation: Beckman Synchron LX20
- B. Materials
 - 1. Beckman Synchron CX Micro Sample Tube (*Part #448774*)
 - 2. S/P Plastic Transfer Pipet (*Cat. #P5214-10*)
 - 3. S/P Brand Accutube Flange Caps (*Cat. #T1226-37*)
- C. Reagent Preparation: Beckman Synchron Systems Iron Reagent (*Part #467910*).
 - 1. No preparation required.
 - 2. When stored unopened at 2-8°C, the reagent is stable until the expiration printed on the label.
 - 3. When first opened or installed on the instrument, the reagent is stable for 60 days unless the expiration date is exceeded.
 - 4. Do not freeze.
- D. Standards Preparation: No preparation required.
 - 1. Synchron Iron/TIBC Calibrator Kit (*Part #442772*).
- E. Control Material
 - 1. Beckman Triad Custom Unassayed Chemistry Control Serum (*Part #465405*).
 - ∪ In use through August 23, 2002.
 - 2. Bio-Rad Liquid Unassayed Multiqual (*Cat. #697, 699*).
 - ∪ In use from August 24, 2002
 - ∪ Thaw new bottle weekly. Mix very well, using rocker prior to use.
 - ∪ Thawed control is stable 7 days. Mix well prior to each use.
- F. Use disposable labware whenever possible. Rinse glassware with 0.1 N Hcl before use.

Iron in Serum

NHANES 2001-2002

7. CALIBRATION AND CALIBRATION VERIFICATION PROCEDURES

- A. Calibrators: Synchron Iron/TIBC Calibrator Kit (*Part #442772*).
 - 1. Store at ambient temperature.
 - 2. Calibrators are stable until expiration date on bottle when stored at ambient temperature.
 - 3. The bottles of calibrator solutions should be kept tightly closed, except when drops are being dispensed. Evaporation and/or contamination will result in erroneous assay values.
 - 4. Caution. The calibrator solutions contain HCl, pH<2, which is corrosive. Do not pipette by mouth. Protective clothing, gloves, and safety glasses should be worn when handling this product. Avoid contact with eyes and skin. If spilled, flush with water.
- B. Calibration:
 - 1. Calibration frequency:
 - a. Fourteen days for each individual reagent cartridge.
 - b. Note: Within-lot calibration is not available for Iron.

8. PROCEDURE OPERATING INSTRUCTIONS; CALCULATIONS; INTERPRETATION OF RESULTS

- A. Preliminaries
 - 1. Enter test in L.I.S. as a part of a panel according to procedure listed in this document (*See Attachment A*).
- B. Sample Preparation
 - 1. Procedure for labeling CX sample tubes and transferring serum (*See Attachment B*).
- C. Operation
 - 1. Refer to Operation Procedures for programming controls/patients and loading sectors/racks in the Beckman LX20 Chemistry Information Manual, 2001 (*See Attachment C* for specific procedure for NHANES samples).
- D. Recording of Data
 - 1. Operator will review results and collate and certify in the L.I.S.
 - 2. Operator will place printouts in box labeled for NHANES samples.
 - 3. Project supervisor will do an Adhoc Report onto a floppy disk in a comma delimited text file from the L.I.S.
 - 4. Comma delimited file is opened in Excel on a PC and copied into another Excel file to further evaluate the data.
 - 5. A printout of the Excel spreadsheet for each container ID results is made and comments noted.
 - 6. Project supervisor reviews the results. If problems noted with patient results or QC, Project Supervisor investigates and discusses issues if necessary with Laboratory Director. Repeat samples if necessary.
 - 7. Daily log sheets are completed and any problems or issues noted.
 - 8. Repeat values are used when they match the original results within 3 CV's.
- E. Replacement and Periodic Maintenance of Key Components (*See Attachment AB* for LX20 Maintenance Schedule).
- F. Calculations

Synchron LX Systems perform all calculations internally to produce the final reported result. The system will calculate the final result for sample dilutions made by the operator when the dilution factor is entered into the system during sample programming.

Iron in Serum

NHANES 2001-2002

9. REPORTABLE RANGE OF RESULTS

- A. Analytical Range:
 - 1. 5-500 µg/dL.
 - a. On samples which are out of instrument range high, repeat test on a dilution of the sample with saline.
 - b. When test is repeated on a dilution, the dilution factor must be entered at the Sample Information Screen.
 - c. If the dilution factor is not entered into the instrument, the printout value must be multiplied by the dilution factor to obtain the final result.
 - 2. Limits of detection (LOD) are established by Beckman Coulter and linearity data verifies the reportable range. Detection of results below the reportable range is not relevant and formal limit of detection study is unnecessary.
 - 3. Sensitivity is defined as the lowest measurable concentration which can be distinguished from zero with 95% confidence. Sensitivity for the iron determination is 5 µg/dL.
 - 4. Samples which are out of instrument range low should be reported as "<5 µg/dL".
 - 5. 0 is not a reportable value.
 - 6. Repeat all irons <5 µg/dL before reporting.

10. QUALITY CONTROL (QC) PROCEDURES

- A. Blind QC Specimens are included in the samples received from NHANES.
- B. Beckman Triad Custom Unassayed Chemistry Controls Levels 2 and 3 are assayed in early A.M. and if a new reagent pack is loaded, controls are assayed again. One level is assayed in middle of the day and both control levels are assayed after running NHANES sample.
- C. BioRad Liquid Unassayed Multiqual Controls Levels 1 and 3 are substituted for Beckman Triad controls as of August 24, 2002 for CDC-NHANES runs to allow long term control use. Multiqual controls are analyzed at beginning and end of runs with CDC-NHANES samples.
- D. Acceptable Answer:
 - 1. Controls must be within ± 2 S.D.
 - 2. Refer to Quality Control Flow Chart for action decisions guidelines (*See Attachment I*).

11. REMEDIAL ACTION IF CALIBRATION OR QC SYSTEMS FAIL TO MEET ACCEPTABLE CRITERIA

Remedial action for out of control conditions includes examination of the pipetting and detection equipment and examination of reagent materials. The QC parameters are compared to the patient means to look for confirmatory or disconfirmatory evidence. When the 2 2s and/or 1 3s rules are violated, samples are repeated following corrective maintenance or reagent changes.

12. LIMITATIONS OF METHOD; INTERFERING SUBSTANCES AND CONDITIONS

- A. Do not use hemolyzed sample. Hemoglobin levels of 60 mg/dL (1+) will elevate results by 12 µg/dL.
- B. Bilirubin 30 mg/dL has no significant interference.
- C. Lipemia has no significant interference.
- D. Copper and magnesium have no significant interference.
- E. Iron-dextran administration can cause elevations of iron with this method.
- F. Ingestion of oral contraceptives will elevate iron or TIBC values.
- G. Refer to References for other interferences caused by drugs, disease and preanalytical variables.

Iron in Serum NHANES 2001-2002

13. REFERENCE RANGES (NORMAL VALUES)

Iron

<i>Serum or Plasma Age Group</i>	<i>µg/dL</i>
Male	50 to 160
Female	40 to 150

Reference Range values were established from wellness participants with an age mix similar to our patients. These data were analyzed using non-parametric techniques described by Reed (Clin Chem 1971;17:275) and Herrera (J Lab Clin Med 1958;52:34-42) which are summarized in recent editions of Tietz' textbook. Descriptions appear in Clin Chem 1988;34:1447 and Clinics in Laboratory Medicine June 1993;13:481.

Pediatric Reference Range Guidelines for Synchron Systems- Multicenter study using data from Montreal, Quebec, Miami, FL and Denver, CO. Beckman 1995

14. CRITICAL CALL RESULTS ("PANIC VALUES")

There are no critical call back values for iron

15. SPECIMEN STORAGE AND HANDLING DURING TESTING

Specimens arrive refrigerated. Specimens are kept refrigerated until ready to transfer to CX multi sample tubes. Capped CX sample tubes are kept refrigerated until ready to put on instrument.

Specimen vials are returned to container and refrigerated after transfer of aliquot and double checking of pour off tubes. Specimen vial container is placed in -70°C Freezer after testing is complete. CX sample tubes are refrigerated, and then frozen after analysis.

16. ALTERNATE METHODS FOR PERFORMING TEST OR STORING SPECIMENS IF TEST SYSTEM FAILS

Samples will remain in refrigerator until instrument is back in operation.

17. TEST RESULT REPORTING SYSTEM; PROTOCOL FOR REPORTING CRITICAL CALLS (IF APPLICABLE)

The collaborating agency with access to patient identifiers or the responsible medical officer is notified by FAX by the Project Supervisor of any critical values. Copies of Faxes sent concerning abnormal results are kept in a folder by the supervisor for the duration of the study.

Test results that are not abnormal are reported to the collaborating agency at a frequency and by a method determined by the study coordinator. Generally, data from this analysis are compiled with results from other analyses and sent to the responsible person at the collaborating agency as a comma delimited file, either through electronic mail or other electronic means.

All data are reported electronically to Westat within 21 days of receipt of specimens.

Internet FTP transfers of files or dial up modem transfer options are available.

Iron in Serum NHANES 2001-2002

18. TRANSFER OR REFERRAL OF SPECIMENS; PROCEDURES FOR SPECIMEN ACCOUNTABILITY AND TRACKING

In general, when specimens are received, the specimen ID number, and a name identifying the container ID and slot number is entered into the Laboratory Information System (L.I.S.) database. New barcodes are printed and the specimens stored in a refrigerator. Samples are aliquoted to a CX-Micro Sample tube with the new barcodes. The specimen ID is read off of the tube by a barcode reader. Tracked in the database are the date and time of entry into the L.I.S., date and time analysis completed, and who certified the results.

Microsoft Excel spreadsheets are used to keep records and track specimens with the data taken from the Laboratory Information System. Logs are kept including information of when samples arrive, are processed and tested, when frozen after testing, and when returned to NHANES for long term storage.

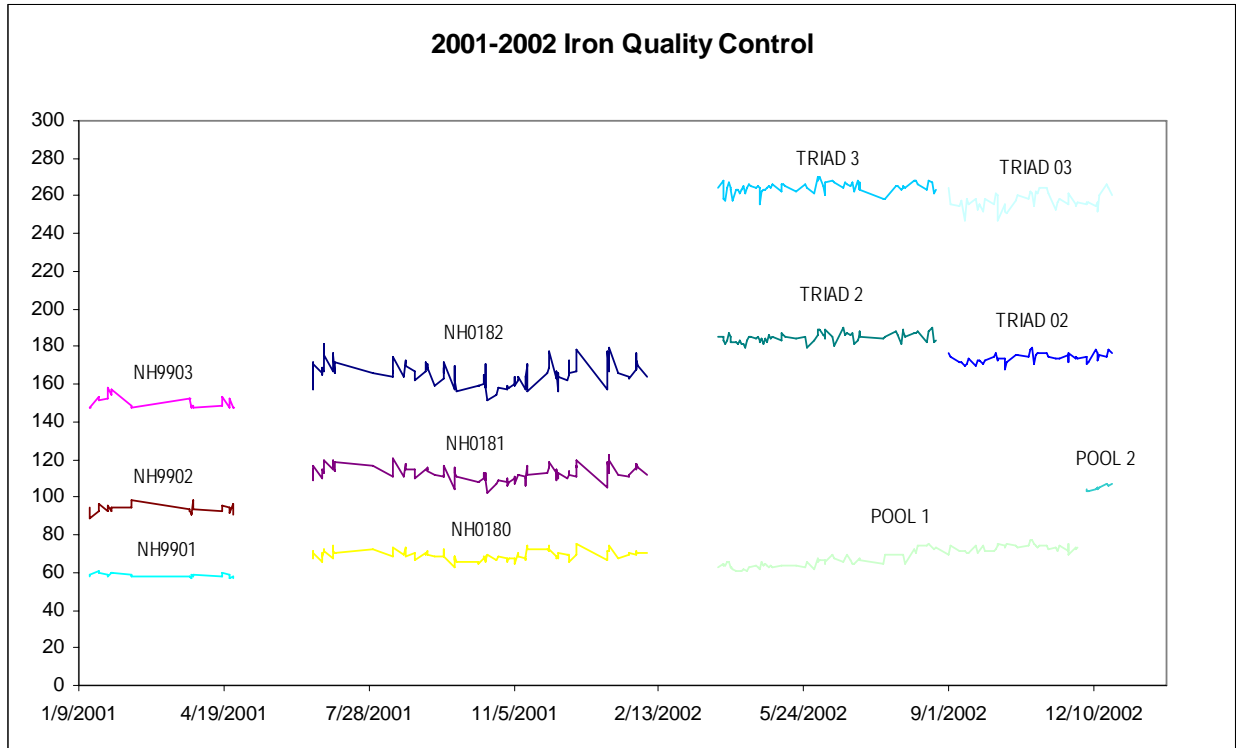
The Project supervisor is responsible for keeping a logbook containing the ID numbers of specimens prepared incorrectly, those with labeling problems, and those with abnormal results, together with information about these discrepancies. It is recommended that records, including related QA/QC data, be maintained for 10 years after completion of the NHANES study.

Iron in Serum NHANES 2001-2002

19. SUMMARY STATISTICS AND QC GRAPHS

Summary Statistics for Iron by Lot

Lot	N	Start Date	End Date	Mean	Standard Deviation	Coefficient of Variation
NH9901	24	1/17/2001	4/25/2001	58.4	1.1	1.8
NH9902	24	1/17/2001	4/25/2001	93.6	2.4	2.5
NH9903	24	1/17/2001	4/25/2001	150.6	3.2	2.1
NH0180	10					
NH0180	9	6/19/2001	2/5/2002	69.3	2.4	3.5
NH0181	10					
NH0181	9	6/19/2001	2/5/2002	113.0	3.8	3.4
NH0182	10					
NH0182	9	6/19/2001	2/5/2002	166.2	6.3	3.8
POOL1	4	3/26/2002	11/29/2002	68.5	4.3	6.3
TRIAD 2	73	3/26/2002	8/23/2002	184.6	2.6	1.4
TRIAD 3	73	3/26/2002	8/23/2002	264.2	2.9	1.1
TRIAD02	49	9/1/2002	12/23/2002	174.3	2.5	1.4
TRIAD03	49	9/1/2002	12/23/2002	257.5	4.1	1.6
POOL2	10	12/5/2002	12/23/2002	104.8	1.5	1.4



Iron in Serum NHANES 2001-2002

REFERENCES

1. Beckman Synchron LX Systems Chemistry Information Manual, 2001.
2. Tietz, N.W. Textbook of Clinical Chemistry, W.B. Saunders, Philadelphia, PA (1986).
3. Tietz, N.W., "Specimen Collection and Processing; Sources of Biological Variation," Textbook of Clinical Chemistry, 2nd Edition, W.B. Saunders, Philadelphia, PA (1994).
4. National Committee for Clinical Laboratory Standards, Procedures for the Handling and Processing of Blood Specimens, Approved Guideline, NCCLS publication H18-A, Villanova, PA (1990).
5. Tietz, N.W., ed., Clinical Guide to Laboratory Tests, 3rd Edition, W.B. Saunders, Philadelphia, PA (1995).
6. National Committee for Clinical Laboratory Standards, How to Define, Determine, and Utilize Reference Intervals in the Clinical Laboratory, Approved Guideline, NCCLS publication C28-A, Villanova, PA (1995).
7. Tietz, N.W., ed., Fundamentals of Clinical Chemistry, 3rd Edition, W.B. Saunders, Philadelphia, PA (1987).
8. Henry, J.B., ed., Clinical Diagnosis and Management by Laboratory Methods, 18th Edition, W.B. Saunders, Philadelphia, PA (1991).
9. Young, D.S., Effects of Drugs on Clinical Laboratory Tests, 4th Edition, AACC Press, Washington, D.C. (1995).
10. Friedman, R.B. and D.S. Young, Effects of Disease on Clinical Laboratory Tests, 3rd Edition, AACC Press, Washington, D.C. (1997).
11. Young, D.S., Effects of Preanalytical Variables on Clinical Laboratory Tests, 2nd Edition, AACC Press, Washington, D.C. (1997).
12. National Committee for Clinical Laboratory Standards, Method Comparison and Bias Estimation Using Patient Samples; Approved Guideline, NCCLS publication EP9-A, Villanova, PA (1995).
13. National Committee for Clinical Laboratory Standards, Precision Performance of Clinical Chemistry Devices, Tentative Guideline, 2nd Edition, NCCLS publication EP5-T2, Villanova, PA (1992).