APHL

June 2025

Quality Practices for Testing Whole Blood for Lead

Exposure to lead—a toxic metal shown to negatively impact neurodevelopment in children at any level of exposure—is best determined by a clinical blood lead test. As efforts to reduce blood lead levels in children continue, care must be taken to accurately measure lower concentrations of lead in blood samples. High-quality blood lead measurements are necessary to ensure proper case management is provided to individual children, and surveillance leads to proper public health interventions for exposed populations.

The US Centers for Disease Control and Prevention (CDC) recommends actions based on a blood lead reference value (BLRV) of 3.5 µg/dL.[a] While such a low reference value is beneficial for ensuring more children with lead exposure are identified, it requires very sensitive and accurate testing capabilities. Because lead is found in the ambient environment, care must be taken to avoid contamination of specimen collection and testing supplies, and to use practices that do not contaminate the specimen throughout the sampling and testing processes.

This quality improvement checklist provides guidance for reliable sampling and measurement of blood lead.

Inside the Guide

a The BLRV of 3.5 µg/dL is based on the 97.5th percentile of the blood lead values among US-based one- to five-year-olds in the 2015–2016 and 2017–2018 National Health and Nutrition Examination Survey cycles.

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Blood Sample Collection

Ensuring an accurate blood lead level result begins with minimizing contamination during the sample collection phase:

Collection Supplies

- ☐ Use supplies designated for trace-metal testing and encourage clinical partners to do the same. Evacuated blood tubes with royal blue-tops (for "trace element testing") and tan-tops ("for lead testing") are acceptable for collecting venous blood for lead testing, but the designation of "sterile" does not indicate that the device is free of metals contamination.
- ☐ If supplies designated for trace-metal testing are unavailable, screen each lot of sampling and testing supplies for lead contamination.
- ☐ EDTA is the preferred anticoagulant;[b, c] avoid heparin anticoagulant because clots may form in the blood after collection (e.g., >24 hours).

Collection Procedures

- ☐ Provide detailed written instructions about specimen collection, specimen rejection criteria, handling and transport, and specimen rejection criteria to clinical providers who will be collecting the specimens.
- ☐ Collect blood samples in a clean environment to prevent contamination, away from known sources of lead (e.g., soil, paint, dust).
- ☐ Use venipuncture samples as the preferred specimen type to reduce contamination from the patient's skin. If capillary blood samples are collected, special care must be taken to minimize contamination:
  - ☐ Ensure a source of clean running water is available for hand washing with soap (use bottled water, if necessary).
  - ☐ See Resources 3-5 at the end of this document for additional precautions.
- ☐ If samples are being collected for additional testing, collect venous blood tubes for metals analysis first to prevent lead contamination carrying over from tubes not pre-screened for lead.

Specimen Selection

- ☐ Check specimens for rejection criteria. Do not test specimens that qualify for rejection.
- ☐ Reject specimens with clots, as lead will be preferentially found in the red blood cells in the clot.

Specimen Storage

- ☐ Store tubes at refrigerated temperatures (+2 °C to +8 °C); freezing blood collection tubes may crack the tubes. Lead is reported to be stable in blood at refrigerated temperatures (+2 °C to +8 °C) for at least 10 weeks in vacutainer tubes[d] and 36 months in sealed polypropylene cryovials.

b Clinical and Laboratory Standards Institute (2024). Measurement Procedures for the Determination of Lead in Whole Blood. 3rd ed. CLSI guideline C40 (ISBN 978-1-68440-219-9 [Electronic]). Available from: clsi.org/shop/standards/c40/

c US Centers for Disease Control and Prevention (2018). Improving the collection and management of human samples used for measuring environmental chemicals and nutrition indicators [Federal Guidance]. Retrieved March 12, 2025 from: www.cdc.gov/biomonitoring/pdf/lead-fingerstick-poster-508.pdf

d Wang ST, Peter F (1985). The stability of human blood lead in storage. Journal of analytical toxicology, 9(2), 85–88. doi.org/10.1093/jat/9.2.85

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The Laboratory Environment

It is essential to keep the laboratory space as clean as possible to reduce potential contamination of the samples.

Sources of Ambient Contamination

To minimize contamination from the ambient environment:

- ☐ Keep corrugated cardboard and brown recycled paper out of the laboratory.
- ☐ Use shoe cleaners and tacky mats at entrances to collect dust and dirt.
- ☐ Provide shoe covers at the laboratory entrance.
- ☐ Limit outside traffic in the laboratory/secure access.
- ☐ Utilize biosafety cabinets (BSC) for sample preparation.
- ☐ Spread plastic-backed laboratory covers (diapers) on laboratory benchtop areas.[e]

Preventive Laboratory Practices

To ensure laboratory processes and practices do not contribute to contamination:

- ☐ Train laboratory scientists to use laboratory practices that minimize the likelihood of specimen contamination.
- ☐ Install an autosampler enclosure to prevent airborne contamination of the specimens.
- ☐ Provide airflow either through filtered (e.g., HEPA or ULPA) fans or by attaching to building exhaust.
- ☐ Test environmental samples and clinical specimens in different laboratory spaces.
- ☐ Develop detailed cleaning and decontamination procedures for the laboratory.[e]

Sample Preparation

Safety Equipment

- ☐ Use universal precautions when working with clinical specimens to prevent exposure to bloodborne pathogens.
- ☐ Work within a BSC to protect both the worker and the sample because air entering the cabinet is HEPA-filtered before being directed to the work surface.[e]
- ☐ Prepare analytical standards and reagents in a chemical fume hood.
- ☐ Wear appropriate personal protective equipment, including lab coat, safety glasses and nitrile gloves.

Reagents and Supplies

- ☐ Use high quality reagents (e.g., double distilled) that have lower background levels of lead.
- ☐ Access to high quality lab water (≥18.2 MΩ-cm) is critical.
- ☐ Acid wash bottles and flasks used for reagents before each use; dedicate to lead testing and periodically verify background levels in dedicated containers.

Quality Control

- ☐ Lot screen tubes and autosampler vials used for testing lead.
- ☐ Before removing an aliquot, mix blood using a vortex, a rocker or pipette pump to ensure homogenous sample.
- ☐ Inspect blood samples and sample dilutions for clots; reject those with clots.
- ☐ Check lead background levels of reagents before preparing samples, including diluent before and after the dual- syringe diluter, and water that will be used in sample preparation.[e]

e Clinical and Laboratory Standards Institute (2024). Measurement Procedures for the Determination of Lead in Whole Blood. 3rd ed. CLSI guideline C40 (ISBN 978-1-68440-219-9 [Electronic]). Available from: clsi.org/shop/standards/c40/

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Analytical Instrumentation

- ☐ Develop performance and maintenance checklists based on manufacturer and laboratory developed test specifications.
- ☐ Include areas for recording:
  - ○ Instrument and maintenance checks prior to instrument operation (ICP: prior to plasma ignition).
  - ○ Performance measures that can be checked against manufacturer and laboratory developed test specifications (ICP: performance measures after plasma ignition).
  - ○ Checklist to ensure daily optimizations are incorporated into run parameters.
  - ○ Checklist for periodic maintenance.
  - ○ Documentation of supervisor's review.

Quality Management Systems

A quality management system (QMS) describes how laboratories perform internal audits to ensure acceptable performance. It assures the integrity and traceability of laboratory results. The internal audits may focus on a specific area of the quality system and may be conducted by laboratory quality assurance (QA) officers, senior management or others from within the laboratory. The QMS guides a laboratory in implementing an overall quality policy that encompasses QA (plans that guide laboratory activities) and quality control (QC, measures to ensure compliance); both are required elements of the overarching QMS.[f]

A robust quality management system includes: duplicates, second source, verifications, staff training, conformance and corrective actions, demonstration of proficiency, a document control system, management of equipment, supplies and inventories, finances and budgeting, to meet certification and/or accreditation standards.

The responsible analyst and supervisor (or designee) should:

- ☐ Review all analytical data to verify quality control compliance. Review transcription for errors if data capture is not used.
- ☐ Follow your laboratory standard operating procedure for confirmatory repeat and/or reflex testing for all specimens which initially result in blood lead levels greater than or equal to 3.5 µg/dL.
- ☐ Conduct proficiency testing at appropriate ranges.

f Association of Public Health Laboratories (2019). Guidance for Laboratory Biomonitoring Programs. Retrieved May 20, 2025 from www.aphl.org/aboutAPHL/publications/Documents/EH-Oct2019-Biomonitoring-Guidance.pdf

Resources

1. The stability of human blood lead in storage (Journal Article: Wang ST, Peter F, 1985)
2. Assessing the stability of Cd, Mn, Pb, Se, and total Hg in whole human blood by ICP-DRC-MS as a function of temperature and time (Journal Article: Tevis DS, et al., 2018)
3. Steps for Collecting Fingerstick Blood Samples in Micro-Vials for Lead Testing (Fact sheet: CDC, 2021)
4. Mission Unleaded: How to test children for lead with maximum accuracy (Video: CDC, 2018)
5. CLSI guideline C40: Measurement Procedures for the Determination of Lead in Whole Blood , 3rd ed. (Book/PDF: Clinical and Laboratory Standards Institute [CLSI], 2024)
6. Improving the collection and management of human samples used for measuring environmental chemicals and nutrition indicators (Federal Guidance: CDC, 2018)
7. The Importance of Lot Testing for Pediatric Lead Testing (Webinar: APHL, 2019)
8. Blood Lead Testing in Public Health Laboratories (Survey Report: APHL, 2019).
9. Laboratory Measurement Implications of Decreasing Childhood Blood Lead Levels (Journal Article: Caldwell KL, et al., 2017).
10. LAMP: CDC's Lead and Multi-element Proficiency Program (Fact Sheet: CDC, 2008)
11. Blood Lead Testing: Sending Specimens to the State Lab (Fact Sheet: North Carolina State Laboratory of Public Health, 2025)
12. Submitting Blood Lead Specimens to the NCSLPH (Video Tutorial: North Carolina State Laboratory of Public Health, 2025)
13. Guidance for Laboratory Biomonitoring Programs (Technical Publication: APHL,2019)

This project was 100% funded with federal funds from a federal program of $1,005,992, supported by Cooperative Agreement number NU60OE000104 (CFDA No. 93.322), funded by the US Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of CDC or the US Department of Health and Human Services.

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