



NCC Pediatrics Continuity Clinic Curriculum: **Health Maintenance II** *Faculty Guide*



Pre-Meeting Preparation:

Please read the following enclosures, corresponding to the screening procedures:

- 1) Hematocrit or Hemoglobin: “Screening for Iron Deficiency” (*PIR 2002*)
→ excerpt from “Diagnosis and Prevention of Iron-Deficiency and Iron-Deficiency Anemia in Infants and Young Children” (*Pediatrics 2010*)
- 2) Lead: Screening for Lead Exposure (*Excerpts - AAP Policy Statement*)
→ update on Maryland lead testing requirements (2020)
→ update on DC, VA lead screening guidelines (2016)
- 3) Tuberculosis: TB Risk-Assessment Questionnaire; “TST- CDC Fact Sheet”
- 4) Dyslipidemia: Screening for Dyslipidemia (*Excerpts- AAP Statement*);

Homework:

* **Bring in an article or resource** addressing a “clinical controversy” or “current event” related to this week’s screening procedures (e.g. unclear benefits of universal iron deficiency or lipid screening)

Conference Agenda:

- Review Health Maintenance II
- Complete Health Maintenance II Cases
- **Round-table discussion** of “clinical controversy”/ “current events” articles

Post-Conference: Board Review Q&A

Extra-Credit:

- Review these AAP/NHLBI reports:
 - 1) Hct or Hgb: [“Diagnosis & Prevention of Iron Deficiency”](#) (Clinical Report; 2010)
 - 2) Lead: [“Prevention of Childhood Lead Toxicity”](#) (Policy Statement; July 2016)
 - 3) Tuberculosis: [“Pediatric Tuberculosis” Francis J. Curry National TB Center, 2010](#)
 - 4) Dyslipidemia: [“Expert Panel on Integrated Guidelines for CV Health”](#) (NHLBI, 2011)
see algorithms page 132-133
- **Iron Deficiency: Implications Before Anemia** (*PIR, 2021*)
- **Hyperlipidemia** (*PIR, 2020*)
- **TB Screening Tests in Children** (*Heart;and National TB Center*)

Screening for Iron Deficiency

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Objectives After completing this article, readers should be able to:

1. Determine the most common cause of iron deficiency in the United States.
2. Describe the pathogenesis of iron deficiency.
3. List populations at high risk for iron deficiency.
4. Outline the common signs and symptoms of iron deficiency.
5. Specify the American Academy of Pediatrics recommendations for screening for iron deficiency.

In the March and April issues of Pediatrics in Review, we published a two-part article on managing anemia in a pediatric office practice. This article expands on the various tests for iron deficiency, including some relatively new ones. These articles should be read as complementary.—RJH

Introduction

Iron deficiency is the most common nutritional deficiency in the world, responsible for a staggering amount of ill health, lost productivity, and premature death. Although its prevalence in the United States has declined since the late 1960s, iron deficiency with or without anemia still is seen frequently in infants, toddlers, adolescent females, and women of childbearing age. In fact, iron deficiency anemia remains the most common hematologic disease of infants and children.

Definitions

Anemia is defined as a low hemoglobin (Hgb) concentration or red blood cell (RBC) mass compared with age-specific norms. Anemia may be caused by decreased RBC production, increased RBC destruction, or blood loss. Based on the size of the RBC, hematologists categorize anemia as macrocytic, normocytic, or microcytic.

Iron is found in different compartments within the body. Total body iron (measured by ferritin), transport iron (measured by transferrin saturation), serum iron, and other hematologic and biochemical markers are used to describe the degrees of iron deficiency. Iron depletion refers to the earliest stage of diminishing iron stores in the setting of insufficient iron supply. Iron deficiency (without anemia) develops as these iron stores are depleted further and begin to impair Hgb synthesis. Finally, iron deficiency anemia results when the iron supply is insufficient to maintain normal levels of Hgb.

Epidemiology

According to current World Health Organization estimates, most of the world's population may be iron-deficient, and at least one third (approximately 2 billion people) have anemia due to iron deficiency. As recently as the late 1960s, iron

Abbreviations

CHr:	reticulocyte hemoglobin content
FEP:	free erythrocyte protoporphyrin
Hct:	hematocrit
Hgb:	hemoglobin
MCV:	mean corpuscular volume
RBC:	red blood cell
RDW:	red blood cell distribution width
TIBC:	total iron-binding capacity
TfR:	serum transferrin receptor
Tfsat:	transferrin saturation
WIC:	Women, Infants and Children (Special Supplemental Food Program)
ZPP:	zinc protoporphyrin

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Drs Wu and Bernstein have a grant from the Bayer Corporation to study the reticulocyte hemoglobin content test.

deficiency with or without anemia was highly prevalent in the United States. In 1971, the American Academy of Pediatrics Committee on Nutrition promoted the early use of iron-fortified formula instead of cow milk. One year later, the federal government introduced the Special Supplemental Food Program for Women, Infants and Children (WIC) Act to address iron and other nutritional deficiencies.

These initiatives have had a tremendous impact on the health and well-being of children. In one review of children ages 6 to 60 months who were participating in public health programs (such as WIC), the prevalence of anemia declined from 7.8% in 1975 to 2.9% in 1985.

Unfortunately, iron deficiency with or without anemia remains relatively common in the United States. In the third National Health and Nutrition Examination Survey (1988 to 1994), 13% of 1-year-olds, 5% of 2-year-olds, 9% of adolescent females (12 to 15 y), and 11% of women of childbearing age (16 to 49 y) were iron-deficient. Iron deficiency anemia was present in 3% of the toddlers studied, 2% of the adolescent females, and 3% to 5% of the women of childbearing age. Despite efforts at prevention and early detection, severe cases still occur.

The high prevalence of iron deficiency anemia in developing countries most often is attributed to nutritional deficiencies worsened by chronic blood loss due to parasitic infections and malaria. In the United States and other industrialized nations, the most common cause of iron deficiency with or without anemia is insufficient dietary iron. Infants, toddlers, adolescents, and pregnant women are particularly susceptible because of their relatively rapid growth and increased demand for iron.

The use of iron-fortified formula helps ensure adequate iron supplies for infants. However, toddlers often have diets that contain minimal amounts of iron-rich foods and large amounts of cow milk. The early introduction of whole cow milk (before 1 year of age) and consumption of greater than 24 oz of whole cow milk per day (after the first year of life) increase the risk of iron deficiency. Cow milk is low in iron and interferes with iron absorption. In addition, cow milk may cause occult gastrointestinal bleeding in some infants.

Adolescent females may become anemic due to menstrual losses. Some children develop anemia due to other causes of blood loss, such as Meckel diverticulum, chronic epistaxis, or inflammatory bowel disease.

Anemia seen during the first 2 to 3 months of life, termed physiologic anemia of infancy, is not due to iron deficiency and, therefore, does not respond to iron therapy. In preterm infants, this physiologic anemia, also called anemia of prematurity, appears at 1 to 2 months of age and is often more severe.

Pathogenesis

Iron, which is present in trace amounts in every cell in the body, performs several vital functions, including oxygen transport. Most of the body's iron is used to make heme groups within the oxygen-carrying molecules Hgb and myoglobin. Iron also is essential for the biologic function of cytochromes and other enzymes involved in cellular respiration.

The early introduction of whole cow milk (ie, before 1 year of age) and consumption of greater than 24 oz/d after the first year of life increase the risk of iron deficiency.

Iron is absorbed from the gastrointestinal tract and transported in the blood bound to transferrin. Excess iron is stored primarily in the liver, bone marrow, and spleen as ferritin.

The developing fetus builds iron stores from maternal supplies. Unless maternal iron deficiency is severe, a normal term infant is born having sufficient iron stores for at least 4 to 6 months of postnatal growth. During the first months of life, the newborn uses iron at a high rate for accelerated growth and expansion of blood volume. By 4 months of age, an infant's iron stores have decreased by 50% (and birthweight usually has doubled). The preterm infant has less time to accumulate iron in utero and, therefore, is born with lower iron stores. In addition, the preterm infant has a demonstrably faster rate of postnatal growth than the term infant and may deplete iron stores within 2 to 3 months.

Adequate iron must be available to meet these demands. Although the majority of iron in the body is conserved and reused, some is lost through the gastrointestinal tract, skin, and urine. During the first year of life, normal infants need to absorb approximately 0.8 mg/d of dietary iron (0.6 mg for growth, 0.2 mg to replace ongoing losses).

Toward the end of the second year of life, this swift

rate of growth begins to slow, so routine diets tend to include sufficient iron-rich foods to meet demands. Iron requirements increase again during adolescence due to rapid growth; adolescent females need additional iron to replace losses from menstruation.

There are two types of dietary iron: heme and non-heme. Heme iron already has been incorporated into the heme molecules of Hgb and myoglobin and is well absorbed by the body. Approximately 10% of the iron in a typical Western diet is heme iron, derived from meat, poultry, and fish. The majority of dietary iron is non-heme, in the form of iron salts. The bioavailability (amount absorbed by the body) of nonheme iron is highly variable and influenced by several factors, including current diet and the amount of iron already present in the body. Bran, dietary fiber, calcium, tannins (in tea and coffee), and oxalates, phytates, and polyphenols (in certain plant-based foods) inhibit iron absorption. Absorption is enhanced by reducing substances such as hydrochloric acid and ascorbic acid. The consumption of heme iron, even in small amounts, enhances the absorption of nonheme iron. Absorption of iron also is increased when total body stores are decreased or when the demand for iron increases, such as during adolescent growth spurts.

Mature human milk and cow milk contain the same amount of iron, approximately 0.5 mg/L; fortified formulas contain 10 to 13 mg/L. However, about 50% of iron from human milk is absorbed compared with only 10% from cow milk and less than 5% from iron-fortified formula. The reasons for the enhanced bioavailability of iron from human milk are not well understood, but they include a lower concentration of calcium and a higher concentration of ascorbic acid in human milk.

Clinical Aspects

The signs and symptoms of iron deficiency with and without anemia depend on the degree of deficiency and the rate at which the anemia develops. Children who have iron deficiency or mild-to-moderate anemia may show few, if any, signs or symptoms. Pallor is the most frequent sign of iron deficiency anemia. As the degree of anemia worsens, fatigue, exercise intolerance, tachycardia, cardiac dilatation, and systolic murmurs may develop. Splenomegaly can be found in 10% to 15% of affected patients. Infants and toddlers may demonstrate irritability and anorexia. However, even severe anemia may be asymptomatic; in one study of severe cases, 45% were diagnosed incidentally.

Iron deficiency anemia in infancy and early childhood is associated with developmental delays and behavior disturbances that may be irreversible. Numerous studies

have documented lower test scores of mental and motor development among infants who had iron deficiency and iron deficiency anemia. In some follow-up studies, test results were normal after reversal of the anemia, but in others, developmental delays persisted, despite adequate treatment. The extent and persistence of brain involvement seem to depend on the age at which anemia first develops as well as its degree and duration. Although additional study is needed, the evidence linking iron deficiency and cognitive impairment is compelling. Iron supplements even have been shown to improve learning and memory in nonanemic iron-deficient adolescent females.

Iron deficiency anemia also is associated with poor growth and may produce other systemic abnormalities, such as blue sclerae, koilonychia, angular stomatitis, increased susceptibility to infection, and functional alterations in the gastrointestinal tract. Iron deficiency increases lead absorption and has been associated with pica, which may result in plumbism.

Making the Diagnosis

The differential diagnosis for anemia in children is broad, but it narrows once the anemia is classified further as microcytic. Iron deficiency and thalassemia minor are the most common causes of microcytic anemia in children. Microcytosis also results from lead poisoning, chronic disease (eg, inflammation, infection, cancer), sideroblastic anemia, and other rare conditions.

An array of tests can be used for evaluating anemia, but there is no single “best” test to diagnose iron deficiency with or without anemia. The “gold standard” for identifying iron deficiency is a direct test—bone marrow biopsy with Prussian blue staining. However, bone marrow aspiration is too invasive for routine use, so indirect assays generally are used. Hematologic tests are based on RBC features (eg, Hgb, mean corpuscular volume [MCV]), and biochemical tests are based on iron metabolism (eg, zinc protoporphyrin [ZPP], serum ferritin concentration). Hematologic tests generally are more readily available and less expensive than biochemical tests. However, biochemical tests detect iron deficiency before the onset of anemia and, therefore, may be worth the additional expense because the deleterious effects of iron deficiency appear to begin before anemia develops. A new hematologic test, reticulocyte hemoglobin content (CHr), may help diagnose iron deficiency before anemia is present.

Laboratory Parameters

The various hematologic and biochemical parameters used for screening and diagnosis are discussed below.

Table 1. Hematologic Markers for Identifying Iron Deficiency

Hematologic Marker	Normal	Iron Depletion	Iron Deficiency Without Anemia	Iron Deficiency Anemia
Hemoglobin (g/dL) (g/L)	N ≥11 (110)	N ≥11 (110)	N ≥11 (110)	D <11* (110)
Mean corpuscular volume (fL)	N 70 to 100	N 70 to 100	N 70 to 100	D <70*
Red blood cell distribution width (%)	N <15	N <15	N <15	I ≥15
Reticulocyte hemoglobin content (pg)	N ≥29	N ≥29	D <29	D <29
Reticulocytes	N 1 to 5	N 1 to 5	N 1 to 5	D <1

N = normal, I = increased, D = decreased
 *Values for ages 6 mo to 2 y.

Tables 1 and 2 summarize the values for these parameters along the spectrum from normal to iron deficiency anemia. In most cases, the results from several tests are necessary to make a definitive diagnosis.

Hematologic Markers (Table 1)

Measurement of Hgb, the concentration of oxygen-carrying protein, is a more sensitive and direct test for anemia than is measurement of hematocrit (Hct), the percentage of whole blood that is occupied by RBCs. Anemia generally is defined as Hgb values below the 5th percentile in a healthy reference population: less than 11.0 g/dL (110 g/L) for infants 6 months to 2 years of age. Both measurements are inexpensive, readily avail-

able tests for anemia and are used most commonly to screen for iron deficiency. However, Hgb and Hct are late markers of iron deficiency, are not specific for iron deficiency anemia, and are less predictive as the prevalence of iron deficiency anemia decreases.

The MCV, the average volume of RBCs, is reported in automated analyses, but it also can be calculated as the ratio of Hct to RBC count. MCV is useful for categorizing anemia as microcytic, normocytic, and macrocytic.

The red blood cell distribution width (RDW) measures variations in the size of RBCs and increases with iron deficiency. In one study of adults, high RDW (>15%) was 71% to 100% sensitive and 50% specific in diagnosing iron deficiency. Another study of 12-month-

Table 2. Biochemical Markers for Identifying Iron Deficiency

Biochemical Marker	Normal	Iron Depletion	Iron Deficiency Without Anemia	Iron Deficiency Anemia
Serum ferritin (mcg/dL) (mcg/L)	N 100±60 (1,000±600)	D <20 (200)	D ≤10 (100)	D <10 (100)
Serum iron (mcg/dL) (mcmol/L)	N 115±50 (20.6±9)	N <115 (20.6)	D <60 (10.7)	D <40 (7.2)
Total iron-binding capacity	N 330±30 (59±5.4)	N 360 to 390 (64.4 to 69.8)	N/I 390 to 410 (69.8 to 73.4)	I ≥410 (73.4)
Transferrin saturation (%)	N 35±15	N <30	D <20	D <10
Serum transferrin receptor (nmol/L)	N <35	I ≥35	I ≥35	I ≥35
Zinc protoporphyrin/Heme (mcmol/mol)	N <40	N <40	I ≥40	I ≥70

N = normal, I = increased, D = decreased

old infants found that high RDW ($>14\%$) was 100% sensitive and 82% specific. Because of its relatively low specificity, RDW is not as useful alone as a screening test, but it is used frequently in conjunction with MCV to differentiate among various causes of anemia. For example, RDW is high in iron deficiency anemia, but low in thalassemia minor.

The reticulocyte count measures circulating immature RBCs and decreases with iron deficiency. However, the reticulocyte count increases with blood loss. In severe cases of iron deficiency anemia coupled with blood loss, the reticulocyte count may be slightly elevated. This parameter often is used for assessing the response to iron supplements.

CHr, the concentration of iron-containing protein in reticulocytes, can be measured in some hematology laboratories by using the same automated flow cytometer that provides RBC and reticulocyte indices. CHr has been shown to be an early indicator of iron deficiency in healthy subjects receiving recombinant human erythropoietin. A retrospective laboratory analysis performed on

including iron absorption from meals, infection, inflammation, and diurnal variation.

Total iron-binding capacity (TIBC) measures the availability of iron-binding sites. Extracellular iron is transported in the body bound to transferrin, a specific carrier protein. Hence, TIBC indirectly measures transferrin levels, which increase as serum iron concentration (and stored iron) decreases. Unfortunately, this test also is affected by factors other than iron status. For example, TIBC is decreased with malnutrition, inflammation, chronic infection, and cancer.

Transferrin saturation (Tfsat) indicates the proportion of occupied iron-binding sites and reflects iron transport rather than storage. Tfsat is calculated from two measured values: serum iron concentration divided by TIBC, expressed as a percent. Low Tfsat implies low serum iron levels relative to the number of available iron-binding sites, suggesting low iron stores. Tfsat decreases before anemia develops, but not early enough to identify iron depletion. Tfsat is influenced by the same factors that affect TIBC and serum iron

concentration and is less sensitive to changes in iron stores than is serum ferritin.

Serum transferrin receptor (TfR) also can be detected in some laboratories via immunoassay. This receptor is present on reticulocytes and is shed from the membrane as the reticulocyte matures. With tissue iron deficiency, there is a proportional increase in the number of

transferrin receptors. Although not a readily available test, TfR is useful as an early marker of iron deficiency, but it also may differentiate between iron deficiency anemia and anemia of chronic disease. In one study, TfR was increased in patients who had iron deficiency anemia, but not in patients who had anemia in the setting of acute infection.

ZPP is formed when zinc is incorporated into protoporphyrin in place of iron during the final step of heme biosynthesis. Under normal conditions, the reaction with iron predominates, but when iron is in short supply, the production of ZPP increases and the ZPP/heme ratio becomes elevated. ZPP/heme reflects iron status during hemoglobin synthesis and detects iron deficiency before the onset of anemia. This test is reported most accurately as the ZPP/heme ratio, but it also is reported simply as ZPP. ZPP is not the same as free erythrocyte protoporphyrin (FEP) or erythrocyte protoporphyrin, which is created in the laboratory when zinc is stripped from ZPP and also is used as a marker of iron deficiency without

Zinc protoporphyrin reflects iron status during hemoglobin synthesis and detects iron deficiency before the onset of anemia.

210 children showed that low CHr was the best predictor of iron deficiency compared with Hgb, MCV, serum iron, RDW, and transferrin saturation.

Biochemical Markers (Table 2)

Ferritin is a storage compound for iron, and serum ferritin levels normally correlate with total iron stores. As iron stores are depleted, serum ferritin levels decline and are the earliest marker of iron deficiency. Serum ferritin has high specificity for iron deficiency, especially when combined with other markers such as Hgb. However, the test is expensive and has limited availability in a clinic setting; therefore, it is not used commonly for screening. In addition, serum ferritin is an acute-phase reactant that can become elevated in the setting of inflammation, chronic infection, or other diseases.

Serum iron concentration can be measured directly and generally decreases as iron stores are depleted. However, serum iron may not reflect iron stores accurately because it is influenced by several additional factors,

Table 3. Diet Counseling to Prevent Iron Deficiency in Children

Age of Child	Preventive Counseling
Birth	<ul style="list-style-type: none"> Encourage breastfeeding exclusively for 4 to 6 months after birth and continue breastfeeding until 12 months of age. For infants who are not breastfed, recommend only iron-fortified formula (10 to 12 mg/L). For breastfed infants who were preterm or of low birthweight, recommend 2 to 4 mg/kg per day of iron drops to a maximum of 15 mg/d and screen for anemia before 6 months of age.
4 to 6 months	<ul style="list-style-type: none"> Recommend starting iron-fortified infant cereal.
6 months	<ul style="list-style-type: none"> Recommend two or more servings per day of iron-fortified infant cereal to meet iron requirements. Recommend one feeding per day of foods rich in vitamin C (fruits and vegetables) to improve iron absorption.
9 to 12 months	<ul style="list-style-type: none"> Begin introducing plain pureed meats. Provide appropriate counseling for vegetarian families. Discourage introduction of cow milk before 12 months of age.
1 to 5 years	<ul style="list-style-type: none"> Encourage iron-rich foods. Limit milk consumption to 24 oz/d.
≥6 years	<ul style="list-style-type: none"> Encourage iron-rich foods and foods rich in vitamin C to improve iron absorption, especially in menstruating females.

anemia. Although ZPP and FEP can be measured by using affordable, clinic-based methods, both are elevated with lead poisoning and chronic disease, making them less useful for the diagnosis of anemia.

Diet

Dietary history may be suggestive of iron deficiency and has been studied as a possible marker for microcytic anemia. In one study of healthy inner-city children between the ages of 15 and 60 months, dietary iron deficiency was defined as: 1) fewer than 5 servings per week each of meat, cereals or bread, vegetables, and fruit; 2) more than 16 oz per day of milk; or 3) daily intake of fatty snacks or sweets or greater than 16 oz of soda. As a screening test for microcytic anemia, the study found that diet history had 71% sensitivity, 79% specificity, and 97% negative predictive value. Similarly, low specificity was demonstrated in another prospective study that used a questionnaire to assess diet, WIC participation, and medical and family history. Response to a clinical trial of iron therapy is used by most clinicians as a practical method of diagnosing iron deficiency anemia.

Because of the low specificity of dietary history for iron deficiency anemia, it cannot eliminate the need for further laboratory testing. However, dietary history may be useful in identifying children at low risk for iron deficiency (negative predictive value) and is essential

for the prevention and management of iron deficiency anemia.

Prevention

Clinicians play an essential role in preventing iron deficiency and its related medical and developmental problems. Primary prevention involves counseling at routine health supervision visits from infancy through adolescence to help ensure that ingestion of dietary iron is adequate (Table 3). Secondary prevention involves regular screening, prompt diagnosis, and appropriate treatment of iron deficiency.

Hgb and Hct are the most commonly used screening tests for iron deficiency. They are readily available and cost-effective markers of anemia. However, the use of anemia as a marker for iron deficiency depends on the prevalence of iron deficiency anemia in a population.

Increased prevalence improves the positive predictive value of anemia as a screening test for iron deficiency.

The American Academy of Pediatrics recommends universal screening with Hgb or Hct once between ages 9 and 12 months of age and again 6 months later in communities and populations that have a high prevalence of iron deficiency anemia, including children eligible for WIC, children of migrant workers, or recently arrived refugee children. For communities that have low rates of anemia, selective screening at the same intervals is recommended for children at risk for iron deficiency, including preterm or low-birthweight infants, infants fed a diet of noniron-fortified infant formula, infants introduced to cow milk before age 12 months, breastfed infants who are receiving inadequate dietary iron after age 6 months, and children who consume more than 24 oz of cow milk per day.

After 2 years of age, routine screening usually is not necessary. Risk can be assessed regularly and children screened who have a previous history of iron deficiency, evidence of low iron intake, or special health needs that increase the risk for iron deficiency (eg, chronic infection, inflammatory disorders, chronic or acute blood loss, restricted diets, use of medications that interfere with iron absorption).

The American Academy of Pediatrics recommends screening all adolescents once between ages 11 and 21

years and screening menstruating females annually. The Centers for Disease Control and Prevention recommend annual screening of adolescent females if their risk is increased (eg, excessive menstrual blood loss, low iron intake, previous diagnosis of iron deficiency); otherwise, anemia should be screened for every 5 to 10 years.

In the appropriate clinical setting, an abnormally low Hgb or Hct combined with a dietary history of low iron intake strongly suggests iron deficiency anemia. Further laboratory testing, such as measurement of serum ferritin, will help to confirm the diagnosis, but in most cases is not necessary. Response to a therapeutic trial of supplemental iron is considered clinically diagnostic. If a child who has a normal diet that contains adequate servings of iron-rich foods is anemic, additional evaluation may be indicated to look for blood loss (eg, occult rectal bleeding).

Presumptive iron deficiency is treated with oral iron salts, most commonly over-the-counter ferrous sulfate, which is inexpensive and relatively well absorbed. Dosages are calculated for elemental iron: children receive 3 to 6 mg/kg per day (qd or tid), and adolescents receive 60 mg/dose (qd or bid). If the iron deficiency is nutritional, the response to iron typically is rapid. Parenteral iron can be given if oral iron is not tolerated; intramuscular iron injections usually are not appropriate. Erythrocyte transfusion should be used only if the anemia is causing severe cardiovascular compromise; hypervolemia and cardiac dilatation may result from rapid correction of the anemia.

After 1 month of therapy, the Hgb measurement should be repeated. An increase of 1 g/dL (10 g/L) or greater confirms the diagnosis of iron deficiency anemia. No improvement in Hgb should prompt further evaluation of the anemia with additional laboratory tests, including MCV, RDW, and serum ferritin, and a search for possible sources of blood loss. Iron therapy should be continued for an additional 2 to 3 months after Hgb has returned to a normal level, and Hgb should be remea-

sured approximately 6 months after discontinuation of iron therapy.

The evidence is clear that early diagnosis and adequate treatment of iron deficiency are critical to prevention or reversal of any negative medical or behavioral effects. As advocates for children, pediatricians must screen for this common nutritional deficiency actively and accurately. Hgb and Hct are the most readily available and cost-effective screening tests, but newer tests that detect iron deficiency before the onset of anemia (eg, CHr) are being studied prospectively in healthy infants and may gain widespread acceptance, particularly as the prevalence of iron deficiency anemia decreases.

Suggested Reading

- American Academy of Pediatrics. Iron fortification of infant formulas. *Pediatrics*. 1999;104:119–123
- American Academy of Pediatrics. The use of whole cow's milk in infancy. *Pediatrics*. 1992;89:1105–1109
- Booth IW, Aukett MA. Iron deficiency anemia in infancy and early childhood. *Arch Dis Child*. 1997;76:549–554
- Boutry M, Needlman R. Use of diet history in the screening of iron deficiency. *Pediatrics*. 1996;98:1138–1142
- Brugnara C, Zurakowski D, DiCanzio J, Boyd T, Platt O. Reticulocyte hemoglobin content to diagnose iron deficiency in children. *JAMA*. 1999;281:2225–2230
- CDC. Recommendations to Prevent and Control Iron Deficiency in the United States. *MMWR Morbid Mortal Wkly Rep*. 1998; 47:1–36
- Fairbanks VF. Laboratory testing for iron status. *Hosp Pract*. 1991; 26S:17–24
- Kleinman RE. *Pediatric Nutrition Handbook*. 4th ed. Elk Grove Village, Ill: American Academy of Pediatrics; 1998
- Looker AC, Dallman PR, Carroll MD, Gunter EW, Johnson CL. Prevalence of iron deficiency in the United States. *JAMA*. 1997;277:973–976
- Lozoff B, Jimenez E, Wolf AW. Long-term developmental outcome of infants with iron deficiency. *N Engl J Med*. 1991;325: 687–694
- Oski F. Iron deficiency in infancy and childhood. *N Engl J Med*. 1993;329:190–193
- Yip R, Binkin NJ, Fleshood L, Trowbridge FL. Declining prevalence of anemia among low-income children in the United States. *JAMA*. 1987;258:1619–1623

EXCERPT FROM AAP CPG ON IRON DEFICIENCY

dlers with ID do not have anemia (Table 2). It is also known that there is poor follow-up testing and poor documentation of improved Hb concentrations. In 1 study, 14% of the children had a positive screening result for anemia. However, only 18.3% of these children with a positive screening result had follow-up testing performed, and of that group, only 11.6% had documented correction of low Hb levels.⁷⁷ Therefore, for infants identified with a Hb concentration of less than 11.0 mg/dL or identified with significant risk of ID or IDA as described previously, SF and CRP or CHr levels in addition to Hb concentration should be measured to increase the sensitivity and specificity of the diagnosis. In addition, the AAP, the World Health Organization, and the European Society for Pediatric Gastroenterology, Hepatology and Nutrition also support the use of the measurement of TfR1 as a screening test once the method has been validated and normal values for infants and toddlers have been established.

Another step to improve the current screening system is to use technology-based reminders for screening and follow-up of infants and toddlers with a diagnosis of ID/IDA. Reminders could be incorporated into electronic health records, and there should be documentation that Hb concentrations have returned to the normal range. The efficacy of any program for minimizing ID and IDA should be tracked scientifically and evaluated through well-planned surveillance programs.

SUMMARY

Given that iron is the world's most common single-nutrient deficiency and there is some evidence of adverse effects of both ID and IDA on cognitive and behavioral development, it is important to minimize ID and IDA in infants and toddlers without waiting for unequivocal evidence. Controversies

remain regarding the timing and methods used for screening for ID/IDA as well as regarding the use of iron supplements to prevent ID/IDA. Although further study is required to generate higher levels of evidence to settle these controversies, the currently available evidence supports the following recommendations.

1. Term, healthy infants have sufficient iron for at least the first 4 months of life. Human milk contains very little iron. Exclusively breast-fed infants are at increasing risk of ID after 4 completed months of age. Therefore, at 4 months of age, breastfed infants should be supplemented with 1 mg/kg per day of oral iron beginning at 4 months of age until appropriate iron-containing complementary foods (including iron-fortified cereals) are introduced in the diet (see Table 3). For partially breastfed infants, the proportion of human milk versus formula is uncertain; therefore, beginning at 4 months of age, partially breastfed infants (more than half of their daily feedings as human milk) who are not receiving iron-containing complementary foods should also receive 1 mg/kg per day of supplemental iron.
2. For formula-fed infants, the iron needs for the first 12 months of life can be met by a standard infant formula (iron content: 10–12 mg/L) and the introduction of iron-containing complementary foods after 4 to 6 months of age, including iron-fortified cereals (Table 3). Whole milk should not be used before 12 completed months of age.
3. The iron intake between 6 and 12 months of age should be 11 mg/day. When infants are given complementary foods, red meat and vegetables with higher iron content should be introduced early (Table 3). To augment the iron supply, liquid iron

supplements are appropriate if iron needs are not being met by the intake of formula and complementary foods.

4. Toddlers 1 through 3 years of age should have an iron intake of 7 mg/day. This would be best delivered by eating red meats, cereals fortified with iron, vegetables that contain iron, and fruits with vitamin C, which augments the absorption of iron (Tables 3 and 4). For toddlers not receiving this iron intake, liquid supplements are suitable for children 12 through 36 months of age, and chewable multivitamins can be used for children 3 years and older.
5. All preterm infants should have an iron intake of at least 2 mg/kg per day through 12 months of age, which is the amount of iron supplied by iron-fortified formulas. Preterm infants fed human milk should receive an iron supplement of 2 mg/kg per day by 1 month of age, and this should be continued until the infant is weaned to iron-fortified formula or begins eating complementary foods that supply the 2 mg/kg of iron. An exception to this practice would include infants who have received an iron load from multiple transfusions of packed red blood cells.
6. Universal screening for anemia should be performed at approximately 12 months of age with determination of Hb concentration and an assessment of risk factors associated with ID/IDA. These risk factors would include low socioeconomic status (especially children of Mexican American descent [Table 1]), a history of prematurity or low birth weight, exposure to lead, exclusive breastfeeding beyond 4 months of age without supplemental iron, and weaning to whole milk or complementary foods that do not include iron-fortified cereals or

foods naturally rich in iron (Table 3). Additional risk factors are the feeding problems, poor growth, and inadequate nutrition typically seen in infants with special health care needs. For infants and toddlers (1–3 years of age), additional screening can be performed at any time if there is a risk of ID/IDA, including inadequate dietary iron intake.

7. If the Hb level is less than 11.0 mg/dL at 12 months of age, then further evaluation for IDA is required to establish it as a cause of anemia. If there is a high risk of dietary ID as described in point 6 above, then further testing for ID should be performed, given the potential adverse effects on neurodevelopmental outcomes. Additional screening tests for ID or IDA should include measurement of:

- SF and CRP levels; or
- CHr concentration.

8. If a child has mild anemia (Hb level of 10–11 mg/d) and can be closely monitored, an alternative method of diagnosis would be to document a 1 g/dL increase in plasma Hb concentration after 1 month of appropriate iron-replacement therapy, especially if the history indicates that the diet is likely to be iron deficient.

9. Use of the TfR1 assay as screening for ID is promising, and the AAP supports the development of TfR1 standards for use of this assay in infants and children.

10. If IDA (or any anemia) or ID has been confirmed by history and laboratory evidence, a means of carefully tracking and following infants and toddlers with a diagnosis of ID/IDA should be implemented. Electronic health records could be used not only to generate reminder messages to screen for IDA and ID at 12 months of age but also to document that IDA and ID have been adequately treated once diagnosed.

ADDENDUM

Development of This Report

This report was written by the primary authors after extensive review of the literature using PubMed, previous AAP reports, Cochrane reviews, and reports from other groups.^{1,6,7,48,77}

The report was also submitted to the following sections and committees of the AAP that were asked to comment on the manuscript: Committee on Fetus and Newborn (COFN); Committee on Psychosocial Aspects of Child and Family Health (COPACFH); Section on Administration and Practice Management (SOAPM); Section on Developmental and Behavioral Pediatrics (SODBP); Section on Gastroenterology, Hepatology, and Nutrition (SOGHN); Section on Hematology and Oncology (SOHO); and Section on Breast Feeding (SOBr).

Additional comments were sought from the Centers for Disease Control and Prevention (CDC), the Department of Agriculture (WIC), the National Insti-

tutes of Health (NIH), and the Food and Drug Administration (FDA), because these governmental agencies were involved in the development of the statement and will necessarily deal with its impact. As it was developed it was extensively reviewed and revised by members of the AAP Committee on Nutrition, who unanimously approved this clinical report. It is openly acknowledged that where the highest levels of evidence are absent, the opinions and suggestions of members of the Committee on Nutrition as well as other groups consulted for this statement were taken into consideration in developing this clinical report.

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REFERENCES

1. United Nations Administrative Committee on Coordination/Sub-Committee on Nutrition and International Food Policy Research Institute. *Fourth Report of the World Nutrition Situation*. Geneva, Switzerland: United Nations Administrative Committee on Coordination/Sub-Committee on Nutrition; 2000
2. Sherry B, Mei Z, Yip R. Continuation of the decline in prevalence of anemia in low-

income infants and children in five states. *Pediatrics*. 2001;107(4):677–682

3. Lozoff B, Jimenez E, Smith JB. Double burden of iron deficiency in infancy and low socioeconomic status: a longitudinal analysis of cognitive test scores to age 19 years. *Arch Pediatr Adolesc Med*. 2006;160(11):1108–1113
4. Bruner AB, Joffe A, Duggan AK, Casella JF, Brandt J. Randomized study of cognitive ef-

fects of iron supplementation in non-anemic iron-deficient adolescent girls. *Lancet*. 1996;348(9033):992–996

5. American Academy of Pediatrics, Committee on Nutrition. Iron fortification of infant formulas. *Pediatrics*. 1999;104(1 pt 1):119–123
6. World Health Organization. *Iron Deficiency Anemia: Assessment, Prevention, and Control—A Guide for Program Managers*. Ge-

Detection of Lead Poisoning

How is Lead Poisoning Detected?

Lead poisoning usually is detected by measuring the level in blood. Many screening procedures use capillary blood as point-of-care testing. While finger-prick samples are appropriate for screening tests, all elevated capillary levels should have confirmation with a venous blood draw since capillary tests can yield frequent false positives. An elevated capillary lead level indicates that lead is in the child's environment even if the venous level is low, however, so primary prevention and education should be initiated.

The current [Bright Futures/AAP Periodicity Schedule](#) recommends a risk assessment at the following well-child visits: 6 months, 9 months, 12 months, 18 months, 24 months, and at 3, 4, 5 and 6 years of age. The recommendation is to do a risk assessment, and do a blood lead level test only if the risk assessment comes back positive. According to the AAP and CDC, universal screens or blood lead level tests are not recommended anymore except for high prevalence areas with increased risk factors as described in a [2012 CDC report](#), such as older housing.

Most initial blood lead level tests are now performed as a result of a positive risk assessment or parental concern rather than because children have symptoms that suggest lead poisoning. However, children of all ages who are recent immigrants, refugees, or adoptees are more likely to have elevated blood lead levels and should be screened at the earliest opportunity. Additionally, children who live in lower socioeconomic areas may be at higher risk.

Medicaid-eligible patients also tend to be at higher risk for lead exposure because many live in these lower socioeconomic areas. Many state Medicaid/Early and Periodic Screening, Diagnostic, and Treatment programs require a universal blood lead level test at the 12-month and 24-month visits, no matter the prevalence of elevated levels based on factors such as where the patient lives. While these programs have been directed to transition their requirements to be more in line with prevalence data (targeted screening), most states have not completed these efforts. For more information, see the CMCHS Information Bulletin, [Target Lead Screening Plans](#) or the CDC [Guide For States Interested in Transitioning to Targeted Blood Lead Screening for Medicaid-Eligible Children](#). Pediatricians should ask their state Medicaid office to determine which requirements they should follow when it comes Medicaid-eligible patients. This information is available for most states on the [CDC Web site](#). However, pediatricians may err on the side of caution and obtain a lead level in Medicaid patients and those who they feel are at high risk.

Because of lead's effects on the developing fetus, some states have developed lead screening guidelines for pregnant women. The CDC recently published guidelines on the screening of pregnant women for lead, medical and environmental management, and follow-up of mothers and infants when maternal lead levels are at least 5 micrograms per deciliter. Care of the infant includes measuring cord or neonatal blood lead to establish a baseline. Once the child is born, the guideline calls for an interruption of breastfeeding only if the maternal blood lead level is 40 micrograms per deciliter or more. Above this level, women should pump and discard their milk until after their blood lead level decreases below that benchmark.

For families using tap water to reconstitute infant formula or juice, or where there has been local concern, tap water testing may be recommended. To help determine whether a home's water might contain lead, parents can call the EPA Safe Drinking Water Hotline at (800) 426-4791 or their local health department to find out about water testing. Well water should be tested for lead when the well is new and tested again when a pregnant woman, infant or child less than 18 years of age moves into the home. For a discussion about using well water to feed infants, see the [AAP policy statement](#) on drinking water from private wells. Most water filters remove lead.

When is Diagnostic Testing Warranted?

Some experienced clinicians measure the blood lead level in children with growth retardation, speech or language dysfunction, anemia, and attentional or behavioral disorders, especially if the parents have a specific concern about lead or about health effects from environmental chemicals. However, elevated blood lead levels that continue into school age are unusual, even if peak blood lead level at 2 years of age was high and the child's home exposures have not been addressed. Therefore, a relatively low blood lead level in a school-aged child does not rule out earlier lead poisoning. If the question of current lead poisoning arises, however, the only reliable way to make a diagnosis is with blood lead measurement. Hair or urine lead levels give no useful information and should not be performed.

Resources

[CDC's Childhood Lead Poisoning Prevention Program](#)

[CDC Low Level Exposure Harms Children: A Renewed Call for Primary Prevention](#)

[Pediatric Environmental Health Specialty Unit](#)

[CMCS Targeted Lead Screening Plans](#)

[CMS Guide for States Interested in Transitioning to Targeted Blood Lead Screening for Medicaid-Eligible Children](#)

[Blood Lead Levels in Children: What Parents Need to Know](#)[Where We Stand: Lead Screening](#)

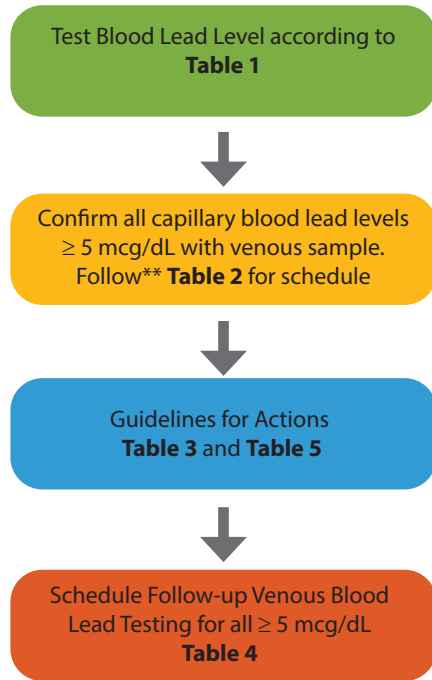


Table 1: Guidelines for Blood Lead Level Testing in Children 6 Months to 72 Months of Age (COMAR 10.11.04, as of 3/28/2016)

For ALL children born on or after 1/1/15, OR on Medicaid									
6 Months	9 Months	12 Months	15 Months	18 Months	24 Months	30 Months	36 Months	48 Months	60 Months
Screen	Screen	Screen	Screen	Screen	Screen	Screen	Screen	Screen	Screen
Test if indicated	Test if indicated	Test Blood Lead Level	Test if indicated	Test if indicated	Test Blood Lead Level	Test if indicated	Test if indicated	Test if indicated	Test if indicated
For children born before 1/1/15, AND not on Medicaid									
6 Months	9 Months	12 Months	15 Months	18 Months	24 Months	30 Months	36 Months	48 Months	60 Months
Screen	Screen	Screen	Screen	Screen	Screen	Screen	Screen	Screen	Screen
Test if indicated	Test if indicated	Test if indicated	Test if indicated	Test if indicated	Test if indicated	Test if indicated	Test if indicated	Test if indicated	Test if indicated
Screening <ul style="list-style-type: none"> Perform Lead Risk Assessment Questionnaire (questions found in Lead Risk Assessment Questionnaire section of this document) Clinical assessment, including health history, developmental screening and physical exam Evaluate nutrition and consider iron deficiency Educate parent/guardian about lead hazards 									
Indicators for Testing <ul style="list-style-type: none"> Parent/guardian request Possible lead exposure to symptoms of lead poisoning, either from health history, developmental assessment, physical exam or newly positive item on Lead Risk Assessment Questionnaire. (Questions can be found in Lead Risk Assessment Questionnaire section of this document.) Follow-up testing on a previously elevated Blood Lead Level (Table 4) Missed screening: If 12 month test was indicated and no proof of test, then perform as soon as possible after 12 months and then again at 24 months. If 24 month test was indicated and no proof of test, then perform test as soon as possible. For more information about lead testing of pregnant and breastfeeding women, see: http://www.cdc.gov/nceh/lead/publications/leadandpregnancy2010.pdf 									

Table 2: Schedule for Confirmatory Venous Sample after Initial Capillary Test**

Capillary Screening Test Result	Perform Venouse Test Within
< 5 mcg/dL	Not Required
5 - 9 mcg/dL	12 weeks
10 - 44 mcg/dL	4 weeks
45 - 59 mcg/dL	48 hours
60 - 69 mcg/dL	24 hours
70 mcg/dL and above	Immediate Emergency Lab Test

Table 3: Abbreviated Clinical Guidance for Management of Lead in Children Ages 6 Months to 72 Months (Full Guidelins in Table 5)

Blood Lead Level	Follow-up Testing	Management
< 5 mcg/dL	On schedule Table 1	<ul style="list-style-type: none"> Continue screening and testing on schedule. Continue education for prevention. If new concern identified by clinician, then retest blood lead level.
5 - 9 mcg/dL	3 months See Table 4	All of above AND: Investiage for exposure source in enviroment and notify health department. <ul style="list-style-type: none"> For more detail consult Table 5
≥ 10 mcg/dL	See Table 4	Consult Table 5

Table 4: Schedule for Follow-up Venous Blood Lead Testing after Blood Lead Level ≥ 5 mcg/dL

Venous Blood Lead Level	Early follow-up testing (2-4 tests after identification)	Later follow-up testing after blood lead level declining
5 - 9 mcg/dL	1 - 3 months ***	6 - 9 months
10 - 19 mcg/dL	1 - 3 months ***	3 - 6 months
20 - 24 mcg/dL	1 - 3 months ***	1 - 3 months
25 - 44 mcg/dL	2 weeks - 1 month	1 month
≥ 45 mcg/dL	As Soon As Possible	As Soon As Possible, based on treatment plan

Seasonal variation in Blood Lead Levels exist, greater exposure in the summer months may necessitate more frequent follow-up.

*** Some clinicians may choose to repeat elevated blood lead tests within a month to ensure that their Blood Lead Level is not rising quickly. (Advisory Committee on Childhood Lead Poisoning Prevention - CDC 2012)

** Requirements for blood lead reporting to the Maryland Childhood Lead Registry are located at COMAR 26.02.01. Reporting is required for all blood lead tests performed on any child 18 years old or younger who resides in Maryland.

Table 5: Clinical Guidance for Management of Lead in Children Ages 0 - 6 years

Confirmed Blood Lead Level (mcg/dL) ¹	< 5	5 - 9	10 - 19	20 - 44	45 - 69	≥ 70
Primary Prevention: parent/guardian education about lead hazards ²	X	X	X	X	X	X
Medical/nutritional history and physical	X	X	X	X	X	X
Follow-up blood lead monitoring ³	X	X	X	X	X	X
Evaluate/treat for anemia/iron deficiency		X	X	X	X	X
Home environmental investigation		X ⁴	X	X	X	X
Exposure/environmental history ⁵		X	X	X	X	X
Coordinate care with local health department		X ⁶	X	X	X	X
Nutritional counseling related to calcium and iron intake		X	X	X	X	X
Obtain developmental and psychological evaluation ⁷			X	X	X	X
Consult with lead specialist, who will also evaluate for chelation therapy				X	X	X
Consider abdominal x-ray (with bowel decontamination if indicated) ⁸				X	X	X
Urgent evaluation for chelation therapy					X	X
Hospitalize for medical emergency						X

¹Refer to information about confirmation of capillary tests in Table 2.

²Includes discussion of pica and lead sources including house paints (before 1978), ceramics, paint on old furniture, soil, foreign travel, traditional folk medicines, certain imported items (candies, food, jewelry, toys, cosmetics, pottery), and parental occupations that can bring home lead dust and debris (e.g., painting, construction, battery reclamation, ceramics, furniture refinishers, radiator repair.)

³Refer to schedule of follow-up blood lead testing in Table 4.

⁴Initial confirmed blood lead of 5 - 9 mcg/dL may require home environmental investigation. Contact LHD for more guidance.

⁵Exposure/environmental history to identify potential lead sources. (See screening questions.) Consider Notice of Defect (information at right) for child living in pre-1978 rental property.

⁶Contact LHD for more information about care coordination for blood lead levels of 5 - 9 mcg/dL.

⁷Use validated developmental screen for levels 10 - 19 mcg/dL, such as Ages and Stages Questionnaire (ASQ). Refer children as appropriate for further evaluation. Children with BLL over 20 mcg/dL should be evaluated in consultation with an experienced clinician, specialist, or LHD regarding further evaluation.

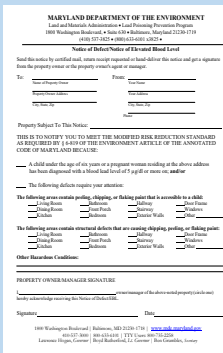
⁸<https://www.cdc.gov/nceh/lead/advisory/acclpp/actions-blls.htm>

Lead Risk Assessment Questionnaire Screen Questions:

1. Lives in or regularly visits a house/building built before 1978 with peeling or chipping paint, recent/ongoing renovation or remodeling?
2. Ever lived outside of the United States or recently arrived from a foreign country?
3. Sibling, housemate/playmate being followed or treated for lead poisoning?
4. Was child tested at 12 and/or 24 months?
5. Frequently puts things in his/her mouth such as toys, jewelry, or keys, eats non-food items (pica)?
6. Contact with an adult whose job or hobby involves exposure to lead?
7. Lives near an active lead smelter, battery recycling plant, or other lead-related industry, or road where soil and dust may be contaminated with lead?
8. Uses products from other countries such as health remedies, spices or food, or store or serve food in leaded crystal, pottery or pewter?

Table 6: Clinical Guidance for Lead Case Closure in Children Ages 0 - 6 years

For children with elevated blood lead levels, case closure will occur after implementation of environmental lead remediation and repeat testing demonstrates a blood lead level below 5mcg/dL. Testing should be repeated every 3 months until at least 2 consecutive tests results with a blood lead level below 5mcg/dL.



A Notice of Defect is a written notice that tells the landlord that there is chipping, flaking or peeling paint or structural defect in the home that is in need of repair. A Notice of Defect may also tell the landlord that a 'Person at Risk' (a child under the age of six or a pregnant woman) has a lead level of 5mcg/dL or above and that repairs need to be made in the home.*

*As of 7/1/20, the action level in Maryland was lowered from ≥ 10mcg/dL to ≥ 5mcg/dL to align with CDC's reference level. (COMAR 26.16.08.03).

The Notice of Defect must be sent by certified mail, return receipt (be certain to retain a copy of the return receipt) and the rental property owner has 30 days to repair the listed defects. It is illegal for a property owner to evict a tenant or raise the rent for reporting problems and/or defects in the home or that a child has been poisoned by lead. To download a copy of the Notice of Defect form, visit: <https://mde.maryland.gov/programs/LAND/Documents/LeadPamphlets/LeadPamphletMDENoticeOfTenantsRights.pdf>

For more information or assistance with filing a Notice of Defect, contact the Maryland Department of the Environment, Lead Poisoning Prevention Program or the Green & Healthy Homes Initiative.

Clinical Resources

Mid-Atlantic Center for Children's Health & the Environment
 Pediatric Environmental Health
 Specialty Unit
 866-622-2431
kidsandenvironment@georgetown.edu
<https://kidsandenvironment.georgetown.edu>

Mount Washington Pediatric Hospital Lead Treatment Program
 410-367-2222
www.mwph.org/health-services/lead-treatment

Maryland Poison Control
 800-222-1222
www.mdpoison.com

American Academy of Pediatrics - Policy Statement: Prevention of Childhood Lead Toxicity
<https://pediatrics.aappublications.org/content/pediatrics/138/1/e20161493.full.pdf>

American Academy of Family Physicians
<https://www.aafp.org/afp/2010/0315/p751.html>

Regulatory Programs and Resources

Maryland Department of Health
 866-703-3266
dhhm.envhealth@maryland.gov
<http://phpa.dhmm.maryland.gov/OEHFP/EH/Pages/Lead.aspx>

Maryland Department of the Environment
 Lead Poisoning Prevention Program
 410-537-3825 | 800-776-2706
<http://www.mde.state.md.us/programs/Land/LeadPoisoningPrevention/Pages/index.aspx>

Local Health Departments
<http://dhmh.maryland.gov/PAGES/DEPARTMENTS.ASPX>

Center for Disease Control and Prevention
<https://www.cdc.gov/nceh/lead/default.htm>

Green & Healthy Homes Initiative
 410-534-6447 | 800-370-5223
www.greenandhealthyhomes.org

National Center for Healthy Housing - Lead Resources
<https://nchh.org/information-and-evidence/healthy-housing-policy/state-and-local/lead>

SCREENING INFORMATION

District of Columbia law requires that all children under the age of six be screened for lead. This “universal screening” requirement is in place because close to 90% of the District’s housing was built prior to 1978, the year lead paint was banned for use in the nation’s housing stock. This means that an overwhelming majority of the children living in the nation’s capital are at risk of exposure to lead paint. Exposure can occur when paint is not well maintained, and it can also occur when renovation or maintenance work is not conducted in a lead-safe manner.

It does not take much exposure to lead for harmful health consequences to occur, and the younger the child, the more potentially serious the health hazard becomes. Pregnant women are also a special risk group, because the lead they are exposed to goes right to the fetus. Adults are also at risk of health consequences when they are exposed to lead, but it generally takes a much heavier dose of lead exposure for harm to occur to an adult than it does for a child. Bottom line: there is no safe level of lead exposure, and the key to prevent harm is to prevent exposure.

District law requires that all children who live here must get screened as follows:

- Between the ages of 6 months and 14 months of age, and again
- Between the ages of 22 and 26 months of age.
- If a child who lives in the District has not been screened at these ages, they must be screened at least once before they are 6 years old.
- District law also requires that all children must be screened before entering daycare, pre-school, or kindergarten. This can be done at any of the above-listed opportunities.

In addition to the above, children should be screened again whenever there is a possibility they have been recently exposed to lead.

If a child is found to have an elevated blood lead level (consisting of 10 micrograms of lead per deciliter of blood or more, expressed as 10 µg/dL or greater), the District Government will provide case management assistance. This consists of a case manager meeting with the child’s family to answer questions the family may have and to provide helpful recommendations to assist the family to prevent further potential harm.

Case management assistance that the District Department of the Environment (DDOE) provides also involves what is called an “environmental investigation.” This is basically a lead inspection of the child’s home and other places that could be where the child got exposed to lead. Once the DDOE investigation is complete, the family will receive a “risk assessment report” which will detail where lead hazards were found. If lead-based paint hazards are found in the child’s home, the property owner will receive instructions about next steps that are needed to eliminate those hazards.

VIRGINIA GUIDELINES

TESTING VIRGINIA CHILDREN FOR LEAD EXPOSURE ¹

ALL MEDICAID ENROLLED CHILDREN ARE REQUIRED TO BE TESTED AT BOTH 12 AND 24 MONTHS OF AGE

To determine risk for other children:

*Blood lead levels shall be obtained in children at ages 12 **and** 24 months of age if they meet ANY one of the criteria noted in the box below. In addition, children over the age of 24 months up to 72 months of age who have not previously been tested and meet ANY one of the criteria in the box below, or experienced a change since testing that has resulted in an increased risk, shall also be tested.*

1. Eligible for or receiving benefits from Medicaid or WIC;
2. Living in or regularly visiting housing or child care facility built before 1960;
3. Living in or regularly visiting housing built before 1978 with peeling or chipping paint or recent (within the last 6 months), ongoing or planned renovations;
4. Living with or regularly visiting housing in which one or more persons have evidence of lead exposure;
5. Living with an adult whose job or hobby involves exposure to lead;
6. Living near an active lead smelter, battery recycling plant, or other industry likely to release lead;
7. The child's parent or guardian requests the child's blood be tested due to any suspected exposure;
8. Recent refugee, immigrant, or child adopted from outside the U.S.

- *Take careful history regarding possible lead exposure at each well-child visit, and provide lead poisoning prevention materials.*
- *Testing may be performed by venipuncture or capillary. Filter paper collection methods are also acceptable and often more convenient for the family if performed in the provider's office.*
- *The use of a CLIA-waived lead testing device approved by CDC and the FDA may be used as a "screening" test, and any level above 5 µg/dL needs to be confirmed by submitting a venous sample to a CLIA-approved laboratory.*

SCHEDULE FOR OBTAINING A CONFIRMATORY SAMPLE ¹

SCREENING TEST RESULT (µg/dL)	PERFORM CONFIRMATORY TEST
5-9	Within 1 to 3 months
10-44	Within 1 week to 1 month (the higher the screening test, the sooner the confirmatory test)
45-59	Within 48 hours
60-69	Within 24 hours
≥ 70	Immediately as an emergency lab test

NOTE: There is no safe lead level, and providers should communicate with parents/guardian any detectable results, and use best medical judgment to assess each child and coordinate follow up testing and care coordination. A venous sample is required for environmental investigations at levels of 20 ug/dL or persistent or rising 15-19 µg/dL.

GUIDELINES FOR MANAGEMENT OF CHILDREN WITH CONFIRMED BLOOD LEAD LEVELS ≥ 5µg/dL ^{2, 3, 4}

BLOOD LEAD LEVEL (µg/dL)	ACTION	TIME FRAME
5-9	Child's healthcare provider: <ul style="list-style-type: none"> • Provides educational materials to include dietary and environmental information • Monitors blood lead level with follow up test 	Within 3 months
10-14	Case manager coordinates with child's healthcare provider: <ul style="list-style-type: none"> • Provides educational materials to include dietary and environmental information • Perform nursing assessment • Follow-up blood lead testing within 30 days to assure not rising • Refer for WIC and social services, if needed 	Within 30 days
15-19	Above actions, plus: <ul style="list-style-type: none"> • Proceed according to actions for 20-44 µg/dL if: A follow-up blood lead is 15 or above, or the blood lead level is increasing 	Within 2 weeks
20-44	Above actions, plus: <ul style="list-style-type: none"> • Coordinate a timely environmental investigation 	Within 1 week
45-69	Above actions, plus: <ul style="list-style-type: none"> • Consider chelation 	Within 48 hours
70 and above	Above actions, plus: Hospitalize child and begin medical treatment (chelation therapy as appropriate) immediately. Contact Emergency Lead Healthcare 866-SOS-LEAD (866-767-5323) for consultation and assistance	Immediate, Within 24 hours

Screening for Lead Exposure

A. Local Requirements

DC has long required screening for lead at both the 12 and 24 month visit. Maryland **has required** a similar venous/capillary lead test at **12 and 24 months**, regardless of where the patient lives since 2015. The clinic has point-of-care lead testing. If POC ("fingerstick" or capillary) lead is abnormal, it should be confirmed via venipuncture sample sent to the lab. **Virginia** still has no requirement for universal screening, but it is prudent to **screen** these children as well.

B. A *Basic* Personal-Risk Questionnaire*

__ Yes	__ No	1. Does your child live in or regularly visit a house or child care facility built before 1950?
__ Yes	__ No	2. Does your child live in or regularly visit a house or child care facility built before 1978 that is being or has recently been renovated or remodeled (within the last 6 months)?
__ Yes	__ No	3. Does your child have a sibling or playmate who has or did have lead poisoning?

* Adapted from the Centers for Disease Control and Prevention. The state or local health department may recommend alternative or additional questions based on local conditions.

* If the answers to the questions are "no," a screening test is not required, although the provider should explain why the questions were asked to reinforce anticipatory guidance. If the answer to any question is "yes" or "not sure," a screening test should be considered.

* Note that all Medicaid-eligible children must be screened both at 1 and 2 years of age.

C. A *Detailed* Clinical Evaluation of the Child with Lead Exposure

Medical history

- Symptoms
- Developmental history
- Mouthing activities; Pica
- Previous blood lead levels
- Family history of lead poisoning

Nutritional history

- Take a dietary history, specifically iron intake
- Access to imported food, cosmetics, folk remedies?
- Food prepared/imported in pottery or metal containers?
- History of food stamps or participation in WIC?

Environmental history

- What is the age and condition of the residence/ other structure in which the child spends time?
- Is there evidence of chewed or peeling paint on woodwork, furniture, or toys?
- How long has the family lived at their residence?

- Have there been recent renovations or repairs to the house?
- Does the home contain vinyl blinds made overseas and purchased before 1997?
- Are the windows new?
- Are there other sites at which the child spends significant amounts of time?
- What is the condition of indoor play areas?
- Do outdoor play areas contain bare soil that may be contaminated?
- How does the family attempt to control dust and dirt?
- Does the child exhibit much hand-to-mouth activity or eating of non-edible objects (pica)?
- Are the child's hands washed before meals and snacks?
- What are the occupations and hobbies of adult household members? (Fishing, working with ceramics or stained glass, and hunting increase risk of lead exposure.)
- Are painted materials or unusual materials burned in household fireplaces?

C. Recommended Follow-up Services, According to Diagnostic BLL

BLL (µg/dL)	Action
<10	No action required
10-14	<ul style="list-style-type: none"> - Obtain a confirmatory venous BLL within 1 month. - If still within this range, provide education to decrease blood lead exposure - Repeat BLL test within 3 months
15-19	<ul style="list-style-type: none"> - Obtain a confirmatory venous BLL within 1 month. - If still within this range, take environmental history and provide education to decrease exposure. - Repeat venous BLL test within 2 months. <p><i>Proceed according to actions for 20–44 µg/dL if:</i></p> <ul style="list-style-type: none"> • The follow-up blood lead concentration is still in this range at least 3 months after initial test; or • Blood lead concentration increases
20-44	<p>Obtain a confirmatory venous BLL within 1 week.</p> <p><i>If still within this range:</i></p> <ul style="list-style-type: none"> • Conduct a complete history & physical (including an environmental and nutritional assessment) • Provide education to decrease blood lead exposure and to decrease lead absorption • Refer the patient to the local health department for case management that should include a detailed environmental investigation with lead hazard reduction and appropriate referrals for support services. • Check CBC and iron stores • Neurodevelopmental monitoring • Abdominal radiography (if particulate lead ingestion is suspected)
45-69	<p>Obtain a confirmatory venous BLL within 2 days.</p> <p><i>If still within this range:</i></p> <ul style="list-style-type: none"> • Begin chelation after consulting clinicians experienced in lead toxicity treatment • Conduct a complete history & physical (including an environmental and nutritional assessment)

	<ul style="list-style-type: none"> • Provide education to decrease blood lead exposure and to decrease lead absorption • Refer the patient to the local health department for case management that should include a detailed environmental investigation with lead hazard reduction and appropriate referrals for support services. • Check CBC and iron stores • Check free EP or ZPP • Neurodevelopmental monitoring • Abdominal radiography (if particulate lead ingestion is suspected)
≥ 70	<ul style="list-style-type: none"> - Obtain a confirmatory BLL immediately. - Hospitalize the patient. - The rest of the management should be as for children with <i>BLL 45-69 µg/dL</i>.

D. Some Prevention Strategies to Decrease Lead Exposure

Source	Prevention Strategy
Paint	Identify and abate
Dust	Wet mop, remove blinds
Soil	Restrict play in area, plant ground cover, wash hands frequently
Drinking Water	Flush cold water pipes by running the water until it becomes as cold as it will get
Parental occupations	Remove work clothing at work; wash work clothes separately
Hand-to-mouth activity (or pica)	Frequent hand washing; minimize food on floor
Inadequate nutrition	Adequate intake of calcium, iron, vitamin C
Some toys, crayons, folk remedies, old cookware	Avoid use

Screening for Tuberculosis (Please read CDC Fact Sheet on next page)

A Basic Risk-Assessment Questionnaire*

- 1) Was your child born outside the United States (Latin America, Africa, Asia)?
 - 2) Has your child traveled outside the United States?
 - 3) Has your child been exposed to anyone with TB?
 - 4) Does your child have close contact with a person who has had a positive TB skin test result?
 - 5) Does your child spend time with anyone who has been in jail or a shelter, uses illegal drugs, or has HIV?
 - 6) Has your child drunk raw milk or eaten unpasteurized cheese?
 - 7) Does your child have a household member who was born outside the U.S.?
 - 8) Does your child have a household member who has traveled outside the U.S.?
-

TB Elimination

Tuberculin Skin Testing

What is it?

The **Mantoux tuberculin skin test (TST)** is the standard method of determining whether a person is infected with *Mycobacterium tuberculosis*. Reliable administration and reading of the TST requires standardization of procedures, training, supervision, and practice.

How is the TST Administered?

The TST is performed by injecting 0.1 ml of tuberculin purified protein derivative (PPD) into the inner surface of the forearm. The injection should be made with a tuberculin syringe, with the needle bevel facing upward. The TST is an intradermal injection. When placed correctly, the injection should produce a pale elevation of the skin (a wheal) 6 to 10 mm in diameter.

How is the TST Read?

The skin test reaction should be read between 48 and 72 hours after administration. A patient who does not return within 72 hours will need to be rescheduled for another skin test.

The reaction should be measured in millimeters of the induration (palpable, raised, hardened area or swelling). The reader should not measure erythema (redness). The diameter of the indurated area should be measured across the forearm (perpendicular to the long axis).

How Are TST Reactions Interpreted?

Skin test interpretation depends on two factors:

- Measurement in millimeters of the induration
- Person's risk of being infected with TB and of progression to disease if infected

Classification of the Tuberculin Skin Test Reaction

An **induration of 5 or more millimeters** is considered positive in

- » HIV-infected persons
- » A recent contact of a person with TB disease
- » Persons with fibrotic changes on chest radiograph consistent with prior TB
- » Patients with organ transplants
- » Persons who are immunosuppressed for other reasons (e.g., taking the equivalent of >15 mg/day of prednisone for 1 month or longer, taking TNF- α antagonists)

An **induration of 10 or more millimeters** is considered positive in

- » Recent immigrants (< 5 years) from high-prevalence countries
- » Injection drug users
- » Residents and employees of high-risk congregate settings
- » Mycobacteriology laboratory personnel
- » Persons with clinical conditions that place them at high risk
- » Children < 4 years of age
- » Infants, children, and adolescents exposed to adults in high-risk categories

An **induration of 15 or more millimeters** is considered positive in any person, including persons with no known risk factors for TB. However, targeted skin testing programs should only be conducted among high-risk groups.

What Are False-Positive Reactions?

Some persons may react to the TST even though they are not infected with *M. tuberculosis*. The causes of these false-positive reactions may include, but are not limited to, the following:

- Infection with nontuberculosis mycobacteria
- Previous BCG vaccination
- Incorrect method of TST administration
- Incorrect interpretation of reaction
- Incorrect bottle of antigen used

(Page 1 of 2)

What Are False-Negative Reactions?

Some persons may not react to the TST even though they are infected with *M. tuberculosis*. The reasons for these false-negative reactions may include, but are not limited to, the following:

- Cutaneous anergy (anergy is the inability to react to skin tests because of a weakened immune system)
- Recent TB infection (within 8-10 weeks of exposure)
- Very old TB infection (many years)
- Very young age (less than 6 months old)
- Recent live-virus vaccination (e.g., measles and smallpox)
- Overwhelming TB disease
- Some viral illnesses (e.g., measles and chicken pox)
- Incorrect method of TST administration
- Incorrect interpretation of reaction

Who Can Receive a TST?

Most persons can receive a TST. TST is contraindicated only for persons who have had a severe reaction (e.g., necrosis, blistering, anaphylactic shock, or ulcerations) to a previous TST. It is not contraindicated for any other persons, including infants, children, pregnant women, persons who are HIV-infected, or persons who have been vaccinated with BCG.

How Often Can TSTs Be Repeated?

In general, there is no risk associated with repeated tuberculin skin test placements. If a person does not return within 48-72 hours for a tuberculin skin test reading, a second test can be placed as soon as possible. There is no contraindication to repeating the TST, unless a previous TST was associated with a severe reaction.

What is a Boosted Reaction?

In some persons who are infected with *M. tuberculosis*, the ability to react to tuberculin may wane over time. When given a TST years after infection, these persons may have a false-negative reaction. However, the TST may

stimulate the immune system, causing a positive, or boosted reaction to subsequent tests. Giving a second TST after an initial negative TST reaction is called two-step testing.

Why is Two-Step Testing Conducted?

Two-step testing is useful for the initial skin testing of adults who are going to be retested periodically, such as health care workers or nursing home residents. This two-step approach can reduce the likelihood that a boosted reaction to a subsequent TST will be misinterpreted as a recent infection.

Can TSTs Be Given To Persons Receiving Vaccinations?

Vaccination with live viruses may interfere with TST reactions. For persons scheduled to receive a TST, testing should be done as follows:

- Either on the same day as vaccination with live-virus vaccine or 4-6 weeks after the administration of the live-virus vaccine
- At least one month after smallpox vaccination

Additional Information

1. American Thoracic Society and CDC. Diagnostic standards and classification of tuberculosis in adults and children. (PDF) *Am J Respir Crit Care Med* 2000; 161. <http://ajrccm.atsjournals.org/cgi/content/ful/161/4/1376>
2. CDC. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care settings, 2005. *MMWR* 2005; 54 (No. RR-17). www.cdc.gov/tb/publications/guidelines/infectioncontrol.htm
3. CDC. Mantoux Tuberculin Skin Test: Training Materials Kit (2003).
4. CDC. Targeted tuberculin testing and treatment of latent tuberculosis infection. *MMWR* 2000; 49 (No. RR-6). www.cdc.gov/MMWR/PDF/rr/rr4906.pdf

<http://www.cdc.gov/tb>

Screening for Dyslipidemia (See Extra Credit "Expert Panel")

A. Recommendations for Lipid Assessment (based on Table 9-5 from article)

Age	Recommendation
Birth- 2yrs	No lipid screening
2-8yrs	Selective screening with Fasting Lipid Profile (FLP) of children with close FamHx lipid disorders ± premature heart disease <i>OR</i> personal RFs for CVD (see Table C)
9-11yrs	Universal Screening x 1 with Non-fasting Lipid Profile (NLP) of Non HDL-C
12-16yrs	Selective screening with FLP if new knowledge of +FamHx or personal RFs
17-21yrs	Universal Screening x 1 with NLP of Non HDL-C

B. Lipid & Lipoprotein Concentration (mg/dL) Cutoffs (based on Table 9-1 from article)

Category	Acceptable	Borderline	High
TC	<170	170-199	≥ 200
LDL-C	< 110	110-129	≥ 130
Non HDL-C*	< 120	120-144	≥ 145
TG			
0-9 years	< 75	75-99	≥ 100
10-19 years	< 90	90-129	≥ 130
HDL-C	> 45	40-45	<40

* Non HDL-C = TC- HDL-C

C. Risk Factors for Cardiovascular Disease (based on Tables 9-6, 9-7 from article)

HIGH LEVEL RISK FACTORS & CONDITIONS
Parent/grandparent history of CV disease < 55 year in males, < 65 year in females: coronary atherosclerosis, MI, peripheral vascular disease, or cerebrovascular disease BMI > 97th percentile (> 95th %ile still moderate risk) Diabetes Mellitus, type 1 or type 2 Hypertension Current smoker Chronic renal disease/end-stage renal disease s/p any solid organ transplant History of Kawasaki's disease with coronary aneurysms (regressed aneurysms <i>moderate risk</i>)
MODERATE LEVEL RISK FACTORS & CONDITIONS
Pre-diabetes: impaired fasting glucose ≥100; impaired glucose tolerance 2hr Polycystic Ovarian Syndrome Chronic Inflammatory Disease (SLE or JRA) HIV Infection Nephrotic syndrome
POTENTIAL RISK FACTORS & CONDITIONS
h/o cancer or congenital heart disease Passive smoker Unknown Family History

Health Maintenance II Quiz

1. For each blood test, list the AAP recommendations for risk assessment and actual testing:
 - a. H/H: **Risk assessment at 4mo, 18mo, 24mo, and yearly > 3yr. Testing at 12mo.**
 - b. Pb: **Risk assessment at 6mo, 9mo, 18mo, and yearly >3yr. Testing at 12 & 24 mo.**
 - c. TB: **Risk assessment at 1mo, 6mo, 12mo, 18mo, 24mo, and yearly > 3yr.**
 - d. Lipids: **2021 Periodicity Schedule recommends risk assessment at 2y, 4y, 6y, 8y, yearly >10yr, with testing at 9-11 and 17-21yrs. 2011 Expert Panel recommends selective screening 2-8yrs and universal screening 9-11yrs and 17-21yrs.**

2. What are the TWO most common age-groups for nutritional iron deficiency and what is the etiology in each of these age groups?
 - (a) **9-24 months:** owing to inadequate intake and inadequate iron stores (iron stores are typically depleted by 6-9 months of age). The typical toddler's diet consists of large quantities of iron-poor cow's milk. Iron-rich foods are thus recommended at 4-6 months to prevent anemia.
 - (b) **Adolescent girls:** because of poor diet, rapid growth, and loss of iron in menstrual blood.

3. Fill in the parameters (Normal, Increased, or Decreased) for the hematologic and biochemical markers for iron deficiency anemia. Which marker is the first to be abnormal?
 - Hemoglobin **decreased** (check Harriet Lane for age-based norms)
 - MCV **decreased** (distinguish from β -thal w/Mentzer index = MCV/RBC)
 - RDW **increased** (high in Fe-defy; low in β -thalassemia)
 - Reticulocytes **decreased** (can use to assess response to Fe therapy)
 - Serum Ferritin **decreased** (**earliest marker of Fe deficiency:** see PIR, pg 175)
 - Serum iron **decreased** (may reflect infection, inflammation, or diurnal factors)
 - TIBC **increased** (also affected by nutritional status, inflammation, cancer)
 - TFN saturation **decreased** (also less sensitive due to above factors)

4. Match the action with the blood lead levels (more than one correct answer):

A. < 10 $\mu\text{g/dL}$	1. Referral to local health department: <u>D, E, F</u>
B. 10-14 $\mu\text{g/dL}$	2. Immediate hospitalization: <u>F</u>
C. 15-19 $\mu\text{g/dL}$	3. Chelation indicated: <u>E, F</u>
D. 20-45 $\mu\text{g/dL}$	4. Detailed environmental history: <u>C, D, E, F</u>
E. 45-69 $\mu\text{g/dL}$	
F. >70 $\mu\text{g/dL}$	

5. Match the following populations with the criteria for positive TST:
 - a. Child with no risk factors: $\geq 15 \text{ mm}$
 - b. Healthy child < 4 years: $\geq 10 \text{ mm}$
 - c. Dr. Jones patient on high-dose steroids: $\geq 5 \text{ mm}$

6. Flashforward: How can you code for these screening tests? Which garners the most RVUs?
 - a. Newborn Screen: **36416 \rightarrow 0 RVU (used to be 0.07)**
 - b. Hgb/Hct: **36415 (Venipuncture by a physician) \rightarrow 0.18 RVU (0 RVU if non-physician)**
 - c. Tuberculin Skin Test: **86580 \rightarrow 0.19 RVU (done in the Allergy Clinic, however)**

Health Maintenance II Mini-Cases

Case 1: You are seeing the 3 year old son of an Egyptian military attaché for a well child visit. What screening would you perform? Consider the *entire* periodicity schedule.

- Height, weight, BMI
- **Blood Pressure** (1st time formal screening done)
- **Formal vision screening** (1st time formal screening done; no hearing until age 4)
- Developmental surveillance (vs. screening)
- Immunizations PRN (review records)
- Risk assessment for Fe-deficiency & lead toxicity
- **TB skin test** (since he was born overseas)
- Cholesterol screening (if there are risk factors, as he is >2y.o.)

Case 2: A 12 month old child has a capillary blood lead level of 14 µg/dL that is 14 µg/dL on follow-up venous testing. Name 4 specific steps the parents can take to decrease lead exposure in their child.

See Chart C: Recommended Follow-up services according to Diagnostic BLL:

- Obtain a confirmatory venous BLL within 1 month.
- **If still within this range, provide education to decrease blood lead exposure**
- Repeat BLL test within 3 months

See Chart D: Prevention Strategies to Decrease Lead Exposure:

Wet mop floors, remove old vinyl mini-blinds, discard old metal cookware, discard painted imported toys, run cold water before drinking, keep clothes used for work or hobbies away from family, eat iron-rich and vitamin-C rich foods, wash hands frequently, hire lead abatement services.

Case 3: A mother asks about screening her 18 month old and 5 year boys for “cholesterol” after their 38 year old father undergoes a coronary catheterization for angina. What do you tell her and what screening will you order?

- **No testing for 18 month old until after 2 years of age**
- **Order fasting lipid profile (FLP) for 5 year-old, since + FamHx:**
 - Guidelines recommend averaging to FLPs, with 2wks-3 months btwn samples.
 - HIGH cutoff for LDL is >130; TG is ≥100 → this dictates management (*see Figures 9.1 & 9.2 in “Expert Panel” for management algorithms; in general, if elevated, dietary/lifestyle interventions are made and FLP redrawn in 6-12mo*).

Bonus: What is the rationale for universal screening at 9-11yrs?

The 2011 guidelines are based on evidence that children with elevated cholesterol develop early atherosclerosis, 30-60% of children with dyslipidemias are missed using the old selective screening methods, and early treatment of cardiovascular risk factors in youth is effective. (*Age 9-11yrs was chosen because this precedes the pubertal drop in LDL cholesterol levels*).

Case 4: You screen a 12mo with PMHx of Hemoglobin C trait on his newborn screen and obtain the CBC below. He was recently weaned from breast milk to whole milk, and mother reports that he takes 32-40oz per day. He still prefers Gerber purees—mostly fruits and vegetables—to table foods. Lead screening was normal. **What is your working diagnosis? What additional testing do you want, if any? What interventions, if any will you take today?**

CBC W/Diff	Result
WBC	10.3
RBC	4.85
Hemoglobin	9.6 (L)
Hematocrit	29.0 (L)
MCV	59.9 (L)
MCH	19.9 (L)
MCHC	33.1
RDW CV	25.0 (H)
Platelets	730 (H)
MPV	7.3
Neutrophils	32.4 (L)
Lymphocytes	53.9 (H)
Monocytes	7.2
Eosinophils	6.4
Basophils	0.1 (L)
Neutrophils	3.4
Lymphocytes	5.6 (H)
Monocytes	0.7
Eosinophils	0.7 (H)
Basophils	0.0
Differential Manual	Result
Eosinophils	6 (H)
Basophils	1
Lymphocytes Atypical	2
Anisocytosis	2+
Poikilocytosis	1+
Microcytes	3+
Hypochromia	2+
Target Cells	1+
Schistocytes	RARE
Neutrophils Segmented	33
Lymphocytes	53
Monocytes	5

(1) Suspect **iron-deficiency anemia**, based on microcytic (low MCV), hypochromic anemia with high RDW (RDW distinguishes from thalassemia).

→ Case is somewhat obscured by PMHx of Hemoglobin C trait. Review of [ACT sheet](#) shows that this condition is rarely associated with anemia; therefore, this is a “red herring”.

(2) Management can be approached in 2 ways:

(a) Treat empirically: Most cases of low H/H plus low dietary-Fe can be confirmed with a positive response to a therapeutic trial of supplemental iron (**3-6 mg/kg/day**). Follow-up in **1mo**. A **1g/dL** increase of Hgb confirms the diagnosis. Treat for **2-3 mo** after H/H normalize, then remeasure H/H **6mo** after stopping Fe.

(b) Obtain confirmatory studies: Because of this patient’s PMHx, a **reticulocyte count**, **iron panel** (iron, TIBC, TFN saturation), and **ferritin** were ordered and confirmed the diagnosis. In other cases where Hx or PE is not consistent with Fe –deficiency, may consider obtaining lab eval.

Other points of discussion:

→ The AAP CPG (*see Extra Credit*) recommends universal screening at 12mo with H/H. Some providers order a ferritin, as well; some order ferritin + CRP (b/c ferritin is an acute phase reactant). **What is the practice at WR-B?** A 2010-11 Resident PI Project showed that only 75% of providers are screening for iron-deficiency and by a variety of means. A 2016-2017 Resident PI Project introduced the Hb POC testing to the clinic resulting in more uniform and consistent anemia screening at the 12 month visit.

→ Additional counseling for Fe-deficiency anemia includes **limiting milk to <24oz** per day and increasing **heme-iron sources** (meat, poultry, fish). Take Fe-supplement with Vit C.

Early introduction (at 4-6 months old) of iron rich foods will help prevent iron deficiency. High iron foods include iron-fortified cereals, meats, tofu, white beans, lentils, spinach, and prunes.

Health Maintenance II Board Review

1. You are seeing a 1-year-old patient in your clinic for a health supervision visit. You explain the recommended screening tests for this visit to the medical student who accompanies you.

Of the following, the MOST appropriate recommended screening test at this visit is:

- A. blood lead concentration by fingerstick**
- B. blood lead concentration by venipuncture
- C. complete blood count with differential count
- D. serum ferritin
- E. serum iron

The diagnosis of lead poisoning or increased lead absorption depends on the measurement of blood lead concentrations. In the 1990s, both the American Academy of Pediatrics and the Centers for Disease Control and Prevention recommended universal blood lead screening of 1- and 2-year-old children, but because of the substantial decrease in the prevalence of elevated blood lead concentrations, the criteria for screening are changing in many communities. Thus, it may be helpful to contact your local health department to determine if children in your area are at risk for environmental lead exposure.

Although blood lead concentration can be measured most accurately from a sample obtained by venipuncture, a capillary specimen obtained by fingerstick is the most appropriate screening test for the toddler described in the vignette. The specimen must be obtained carefully to avoid contamination from lead on the skin. Capillary specimen values greater than 10 mcg/dL must be confirmed by a venous sample because of the possibility of skin contamination causing a false-positive result.

Although obtaining a CBC with smear and measuring serum ferritin and serum iron may be useful in the diagnosis and management of children who have anemia, including that associated with environmental lead exposure, these tests are not definitive for determining exposure to environmental lead. Finally, hair evaluation for lead poisoning is neither sensitive nor specific due to the lack of correlation with blood lead values and should not be used.

2. A medical student notes on rounds that a 2-year-old girl admitted for pneumonia has a complete blood count (CBC) that includes a hematocrit of 35% (0.35), hemoglobin of 11.5 g/dL (115.0 g/L), mean corpuscular volume of 68.0 fL, and platelet and white blood cell counts that are normal for age. During the bedside encounter with the child's mother, you advise her to start the child on a multivitamin with iron and have her primary care physician obtain another CBC in a month or so. The medical student asks why you recommended iron supplementation when the child has a normal hematocrit.

Of the following, the BEST reason to prescribe supplemental iron therapy for this child at this time is to prevent

- A. diminished cognitive abilities**
- B. fatigue
- C. rapid progression to anemia
- D. recurrent infections
- E. short stature

The child described in the vignette likely has iron deficiency, as evidenced by her low mean corpuscular volume. Providing iron supplementation may improve her cognition. It is not clear whether effects on cognition and behavior caused by iron deficiency are completely reversible with iron therapy. Of the two studies that treated children for 2 months or longer, one reported dramatic benefits for development and the other did not. Evidence

suggests that children who had iron deficiency as toddlers may have slightly impaired cognition in elementary school, even if they were treated with iron and the anemia resolved. Finally, according to some evidence, iron deficiency may cause or be associated with symptoms of attention-deficit/hyperactivity disorder that may be improved with iron therapy.

For many children, such as the girl described in the vignette, iron deficiency is revealed on a complete blood count obtained because of a febrile illness. Fever may cause transient anemia and microcytosis due to hemolysis, and repeat screening is recommended when the child recovers. Routine iron supplementation with a multivitamin with iron should be prescribed until it is determined whether iron therapy is required.

Iron deficiency has not been proven to cause fatigue in the absence of anemia, and there is no definitive association between isolated iron deficiency or anemia and short stature. Iron deficiency does not cause recurrent infection. Iron deficiency does not lead rapidly to anemia; rather, anemia may develop over weeks to months.

Treatment of iron deficiency anemia involves iron replacement, usually with ferrous sulfate, for at least 2 months after the anemia has been corrected to replenish iron stores. Most children who have mild iron deficiency anemia are asymptomatic and are diagnosed following routine screening as part of health supervision visits, screening based on dietary risk factors, or a complete blood count obtained for evaluation of illness, particularly fever without focus.

3. As you are leaving the supermarket, the cashier tells you that she is worried because her child recently had a positive tuberculin skin test. She had to take him to the health department for skin testing because he had been in contact with her father, who recently was diagnosed with active pulmonary tuberculosis. They told her that the boy's skin test was positive at "25," but his chest radiograph was normal. She is concerned because the doctor told her that the case is a little unusual because of the type of tuberculosis her father has. She asked the physician at the health department to write it down, and she hands you a paper that says "INH resistant." The mother asks you what type of medication her boy should receive.

Of the following, the MOST appropriate antituberculous agent to prescribe for this boy is

- A. ciprofloxacin
- B. ethambutol
- C. isoniazid
- D. pyrazinamide
- E. rifampin**

With a positive tuberculin skin test, a negative chest radiograph, and no indications of active disease, the patient described in the vignette meets the classification of a latent tuberculosis infection (LTBI). LTBI usually is treated with isoniazid (INH) once daily for 9 months, but when the source case is known to have INH resistance, this agent should not be used. Instead, a 6-month course of rifampin is recommended. An exception to this approach would be if the source case was known to be resistant to both INH and rifampin, in which case a tuberculosis expert should be consulted to determine the best course of treatment. Ciprofloxacin, ethambutol, and pyrazinamide are used in combination with other antituberculous agents for the treatment of active tuberculous disease; they are not indicated for monotherapy in treating LTBI.

Although usually very well tolerated, patients who receive rifampin should be aware of possible adverse effects. Urine, tears, and saliva change to a reddish-orange color, which may stain clothes or contact lenses. Rifampin therapy also may be associated with mild "flu-like" symptoms (eg, myalgias) that resolve with continued therapy.

Rifampin also induces cytochrome P-450 activity and, therefore, decreases the half-life of medications such as warfarin, digoxin, thyroxine, oral contraceptives, and some antimicrobial agents (eg, chloramphenicol), making them less effective. When rifampin is used in combination with INH patients are twice as likely to develop hepatitis as are patients treated with rifampin in combination with other antituberculous medications. Thrombocytopenia and leukopenia both have been associated with rifampin therapy exceeding 1 month's duration.

4. A family has just relocated to your community, and you are evaluating their 12-year-old son for the first time this afternoon. Family history reveals that the boy's father and grandmother had premature cardiovascular disease. The boy's parents are concerned about his risk of heart disease.

Of the following, the MOST important next step in this child's evaluation is:

- A. Echocardiography
- B. Electrocardiography
- C. Fasting lipoprotein analysis**
- D. Random cholesterol measurement
- E. Referral to the cardiology clinic

In recent years, an increasing body of literature has indicated that atherosclerotic disease and its effect on the cardiovascular system are progressive processes that begin during early childhood. Research has demonstrated that the complex process of acquired cardiovascular disease is the result of genetic predisposition to disease susceptibility along with factors such as diet, physical activity, and other comorbidities.

In adults, the strongest risk factors for the development of cardiovascular disease include a high concentration of low-density lipoprotein, a low concentration of high-density lipoprotein, elevated blood pressure, type 1 or 2 diabetes mellitus, cigarette smoking, and obesity. Research in children and adolescents has shown that some of these risk factors may be present in early childhood. It is imperative, therefore, for pediatricians to take proactive roles in stressing the importance of healthy cardiovascular lifestyles and identifying children at risk for cardiovascular disease.

The importance of the history, especially the family history, cannot be overemphasized because the clinical manifestations of hypercholesterolemia are variable and may not be physically present until later in childhood, adolescence, or even adulthood. Some children who have homozygous familial hypercholesterolemia may demonstrate cutaneous or tendinous xanthomas, but often these findings are not apparent until early adulthood. As a result, some children who have significant hypercholesterolemia may have normal findings on physical examination.

The American Academy of Pediatrics has adopted the recommendation that children undergo cholesterol screening when there is a family history of premature cardiovascular disease, such as for the boy in the vignette, or when there is a family history of high blood concentrations of cholesterol. It is also important to screen children for whom the family history is not known if there is a history of other risk factors for cardiovascular disease such as obesity, hypertension, or diabetes mellitus. Accordingly, the boy in the vignette should undergo a screening test for lipoproteins that includes cholesterol, high-density lipoproteins, and low-density lipoproteins in the fasting state.

Random cholesterol screening may provide important information, but taken in isolation, will not offer as much information as a fasting lipoprotein panel. Referral to a specialized clinic such as cardiology or endocrinology may be indicated in some patients, but this should be considered only after more complete information is obtained from the diagnostic evaluation. Neither echocardiography nor electrocardiography is indicated for this patient at this time, and neither is used as a screening test for cardiovascular risk factors in children.