

Noninvasive Assessment of Nutritional Iron Status

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In response to the need for improved point-of-care diagnostic technology for the assessment of nutritional iron deficiency and anemia in children, we propose to develop a compact, inexpensive, and noninvasive optical instrument that measures zinc protoporphyrin (a candidate biomarker for iron deficiency) fluorescence through the skin. Although similar devices have been commercially available to perform this assay on clinical blood samples, only with recent advances in light source and detection technologies is it now feasible to develop a simple and affordable device for point-of-care applications. We believe that the development of this noninvasive diagnostic will significantly improve the quality of healthcare by enabling primary caregivers to routinely screen women and children for nutritional iron deficiency; and also by improving patient participation and retention in clinical research relating to nutritional iron deficiency intervention. With the anticipated success of this project, we will be encouraged to investigate other blood analytes and characteristics that may also be measured optically and noninvasively.

As described in the 2004 joint report from the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), iron deficiency with or without anemia has important consequences for human health and child development: anemic women and their infants are at greater risk of dying during the perinatal period; children's mental and physical development are delayed or impaired; and the capacity to do physical work (e.g., productivity) is significantly compromised. Physicians are obliged to make a positive diagnosis of nutritional iron deficiency before prescribing iron supplementation, because iron toxicity can occur if the individual is not iron-deficient.

Despite our understanding of iron physiology and metabolism, there is currently no universally accepted method to assess iron status. We know that iron exists in several forms in different compartments of the body: it is the essential component of *hemoglobin* in blood and of *myoglobin* in tissue – and enables these molecules to carry oxygen throughout the body for respiration. Additional iron is held in reserve in the form of *ferritin*, which is distributed in both blood and tissue. The sequence of events, and the relative rates at which these substances are lost during iron deficiency are not well characterized.

While *in vitro* diagnostic assays are commercially available to measure each of these different analytes, all of these tests require at the minimum a clinical sample of blood or tissue and access to specialized laboratory resources – to implement any of them in remote settings or for routine screening purposes would be costly and impractical. Blood hemoglobin concentration is an exception to this rule, and is frequently used as an indicator of iron status – in part because it can easily be estimated by colorimetry, but also because iron deficiency is most common cause of anemia (which is by definition low blood hemoglobin concentration). It is important to realize, however, that iron deficiency can also exist in the absence of anemia, and that decreased hemoglobin concentration is probably a late-indicator of severe or protracted iron deficiency.