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TITLE: Screening for Iron Deficiency Anemia by Dietary History in a High-Risk Population

AUTHOR: Debra L. Bogen, MD <1>; Anne K. Duggan, ScD <2>; George J. Dover, MD <2>; and Modena H. Wilson, MD, MPH <2>

**ABSTRACT:** Background. Iron deficiency anemia (IDA) in young children is important to identify because of its adverse effects on behavior and development.

Because of costs and inconvenience associated with blood test screening and the decline in prevalence of IDA, the Institute of Medicine and the Centers for Disease

Control and Prevention recommend that blood test screening for IDA be targeted to children first identified by dietary and health history.

**Objective.** To evaluate a parent-completed dietary and health history as the first stage of 2-stage screening for IDA.

**Design and Methods.** A cross-sectional study was conducted in inner-city clinics in children 9 to 30 months old having routine anemia screening as part of a

scheduled visit. Parents completed a questionnaire and children had venous blood sampling for complete blood count and ferritin. Anemia was defined as Hb <11.0

g/dL. Iron deficiency (ID) was defined as ferritin <10  $\mu$ g/L or mean corpuscular volume <70 fL and red cell distribution width >14.5%. Children were

categorized into 1 of 4 groups: iron-sufficient, not anemic (ISNA); iron-sufficient, anemic (ISA); iron-deficient, not anemic (IDNA); and iron-deficient anemic (IDA).

The questionnaire consisted of 15 dietary items in domains of infant diet, intake of solid food, intake of beverages, and participation in the Special Supplemental

Nutrition Program for Women, Infants, and Children together with 14 historical items in domains of birth history, recent illness, chronic medical conditions, history

of anemia, and maternal history. Analysis was performed on individual items, domains, and combinations of selected items.

**Results.** In the 282 study subjects, the prevalence of anemia (35%), IDNA (7%), and IDA (8%) did not vary significantly by age. Among individual historical and

dietary questions, maternal history of anemia and drinking >2 glasses of juice per day identified the highest proportion of children with IDA: 50% sensitivity (95% confidence interval [CI]: 16,81) and 77% sensitivity (95% CI: 54,89), respectively. However, specificities for these questions were 60% (95% CI: 55,65) and 22% (95% CI: 17,27), respectively. Domains of questions with the highest sensitivity for IDA were beverage intake (91%; 95% CI: 68,99) and intake of solid food (91%; 95% CI: 68,99). However, specificities of the domains were only 14% (95% CI: 10,18) and 29% (95% CI: 24,35), respectively. The dietary items used by Boutry and Needlman were 95% (95% CI: 77,99) sensitive but only 15% (95% CI: 11,19) specific for IDA. The recommendations of the Centers for Disease Control and Prevention for health and dietary screening were 73% (95% CI: 56,92) sensitive and 29% (95% CI: 24,35) specific for IDA. The individual questions, domains of questions, and interdomain groups of questions had similar sensitivity and specificity for anemia and ID (IDA + IDNA).

Conclusion. In this high-risk population, neither individual nor combinations of parental answers to dietary and health questions were able to predict IDA, anemia, or ID well enough to serve as a first-stage screening test.

[anemia, iron deficiency, iron deficiency anemia, dietary history, screening.]

TEXT:

ABBREVIATIONS. IDA, iron deficiency anemia; Hb, hemoglobin; ID, iron deficiency; CDC, Centers for Disease Control and Prevention; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; CBC, complete blood count; ISA, iron-sufficient, anemic; ISNA, iron-sufficient, not anemic; IDNA, iron-deficient, not anemic; CI, confidence interval.

Iron deficiency anemia (IDA), resulting from depletion of total body iron and impaired hemoglobin (Hb) production, is associated with diminished cognitive function, changes in behavior, delayed infant growth and development, decreased exercise tolerance, and impaired immune function in children. [n1-n5] IDA may be particularly important for poor children who are already at increased risk for delayed development. [n6,n7] A nutrition objective of Healthy People 2000 is to reduce iron deficiency (ID) among children 1 to 4 years of age, with special attention to low-income and minority children because of their increased risk. [n8]

The prevalence of IDA in infants and young children in the United States has declined in the past 3 decades due to factors, such as iron fortification of infant formula and cereal, increased emphasis on breastfeeding, and delayed introduction of cow's milk into the diet. The decline in the prevalence of IDA, often measured as

anemia, has been documented in a wide range of populations. [n9-n11] Despite these reports of low prevalence, the problem still exists in certain groups. Eden and

Mir [n12] recently documented a 10% prevalence of IDA in minority, urban children 12 to 36 months of age.

The American Academy of Pediatrics recommends that children be screened for IDA using blood for Hb or hematocrit at 6 to 12 months of age and again at 15

months to 4 years of age. [n13] A common practice related to this recommendation is to give children with a low Hb 1 month of daily oral iron therapy and to

repeat blood testing to evaluate for a response to the iron; an increase in Hb of 1 g/dL is considered diagnostic of IDA. [n14] Several factors limit the effectiveness

and feasibility of this practice: the current low prevalence of IDA reduces the predictive value of Hb for IDA, at least 2 blood tests are needed, and compliance with

follow-up visits and iron therapy is poor. [n15] These limitations, together with the pain, time, and expense of blood test screening for IDA in low-risk populations,

have made an alternative to universal blood screening for IDA desirable.

The alternative recommended by the Institute of Medicine and the Centers for Disease Control and Prevention (CDC) is 2-stage screening in which children first

are screened by dietary and health history and only those with identifiable risk factors for IDA have blood testing for IDA. [n16,n17] This is consistent with the

principle that the first stage of a multistage-screening procedure to detect conditions with relatively low prevalence should be able to, at low cost, reduce the total

population to a much smaller one that contains most of the persons with the condition of interest. The smaller group is more manageable and can be examined with

more expensive and/or demanding tests in 1 or more subsequent screening phases. A dietary history shown by Boutry and Needlman [n18] to be significantly

associated with microcytic anemia, with a sensitivity of 71% and a specificity of 79%, suggested that 2-stage screening for IDA was promising.

The objective of the study reported here was to evaluate a broad set of dietary and health history items, including those identified by the CDC [n17] and Boutry and

Needlman, [n18] and to determine whether a subset of items could serve as the first stage of a 2-stage screen for IDA. A sensitivity of  $\geq 95\%$  and a specificity of

$\geq 50\%$  for the identification of IDA were desired.

## METHODS

This cross-sectional study was conducted in children 9 to 30 months of age presenting to an inner-city, pediatric residency continuity clinic and 3 other inner-city

clinics in Baltimore City. Children were eligible if they had a scheduled appointment that included routine screening for anemia by venous blood sampling. Lead

screening was often performed at the same time as anemia screening; therefore, when available, lead levels were recorded for eligible patients. The sites were chosen

because they served low-income, mostly black children who were assumed to be at high risk for IDA. The institutional review boards of all participating institutions approved the study.

The survey questionnaire was developed from a review of the literature concerning risk factors for IDA and from expert opinion. Presence of these factors was considered an at-risk response and was defined as such before the start of the study. Because the questionnaire was designed to be parent-completed, a simple response format was used. All items were answered by circling yes, no, or don't know or by circling the best response.

The questionnaire was organized into domains of risk for IDA. Four dietary domains, infant diet, beverage intake, solid food intake, and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participation contained 15 questions. Infant diet addressed the following risk factors for IDA: use of low iron formula, exclusive breastfeeding without a supplementary source of iron after 6 months of age, and early introduction of cow's milk. Beverage questions addressed intake of juice, soda, and cow's milk. Solid food intake items were based on the dietary history evaluated by Boutry and Needlman, [n18] namely, eat <5 servings per week of each, bread/cereal, meat/beans, fruits and vegetables; and eat daily chips, fried snacks, or sweets. In addition, lack of daily multivitamin use was assessed to determine whether it might be a risk factor. Because WIC participation has been demonstrated to improve iron status in urban children, [n19] absence of current and/or past WIC enrollment was also evaluated as a risk factor for IDA.

Three historical domains (birth, past health, and maternal and family history) contained 14 questions. Risk factors related to birth history included prematurity (<37 weeks), low birth weight (<2500 g), and length of hospital stay >3 days. The past health domain included questions concerning chronic illness, recent illness, doctor visits in the past 3 months, and previous diagnosis and treatment of anemia. Maternal history questions included parity (assuming that increased parity is associated with poorer maternal nutritional status) and anemia during pregnancy or at other times. Family history concerned anemia in other family members, possibly representing a hereditary anemia such as thalassemia trait.

The questionnaire was pretested, revised, and then pretested again from May 1997 to July 1997 in the Harriet Lane Pediatric Clinic, an inner-city primary care clinic that serves as a resident continuity clinic. During pretesting, parents completed the questionnaire after giving informed consent and were then interviewed by the principal investigator to assess the clarity and quality of each item. The questionnaire was completed in <5 minutes. The comments of the parents resulted in minor changes in the questionnaire. A second round of pretesting was completed to assess the changes made after the first pretest and only 1 additional change was made.

Individual items from the questionnaire were combined into 2 summary measures. The first summary measure incorporated the dietary questions used in the study by Boutry and Needlman [n18] and included items: eating <5 servings each of meat, grains, vegetables, and fruit per week; drinking >16 oz per day of milk or soda; and daily intake of fatty snacks or sweets. This summary measure is called Boutry/Needlman. The second summary measure, based on risk factors identified by the CDC, [n17] included low birth weight (<2500 g), prematurity (<37 weeks), use of low-iron formula, consumption of cow's milk before 12 months of age, breastfeeding without at least 2 servings of iron fortified cereal/day at 9 months of age, and intake of >24 oz milk/day. This summary measure is called CDC. The CDC risk categories also include "children with special health care needs," which was not included in the summary measure. In the CDC and Boutry/Needlman summary measures, an at-risk response to any 1 item resulted in the child being classified as at risk for IDA.

Families were recruited from July 1997 through June 1998. The clinic appointment schedules were reviewed daily to identify eligible children. Providers were asked whether they intended to screen eligible children for anemia. If so, parents of such children were approached in the waiting room and invited to participate in the study. In most cases, the parent completed the questionnaire before seeing the physician, and the child had venous blood sampling for complete blood count (CBC) and ferritin determination after the visit. The CBC and ferritin were paid for by the study but results were reported to the pediatrician for action. Laboratory analysis of the CBC was on Coulter Counter, Model S-Plus STKR (Coulter Electronics, Inc, Hialeah, FL) and serum ferritin level was measured using a 2-site immunoenzymatic assay on the Tosoh AIA immunoassay analyzer (Tosoh Medics, Inc, Foster City, CA). All samples were analyzed in a single university laboratory. Lead levels were measured at the state laboratory. Children were included in the study only 1 time.

#### Data Analyses

Anemia was defined as Hb <11.0 g/dL, consistent with criteria for the National Health and Nutrition Examination Survey III. [n11] ID was defined as ferritin <10  $\mu$ g/L or mean corpuscular volume <70 fL and red cell distribution width >14.5%. Children were categorized into 1 of 4 groups: iron-sufficient, not anemic (ISNA); iron-sufficient, anemic (ISA); iron-deficient, not anemic (IDNA); and IDA. The children with IDA and ISA comprise the larger category anemia: those who would be detected by screening with Hb alone, which is the usual practice. The children with IDNA and IDA comprise the larger category: ID.

The sensitivity and specificity for IDA, ID, and anemia were determined for individual questionnaire items and for domains of questions. Any at-risk response to a

single item within a domain resulted in the child being categorized as at risk and, therefore, in need of blood testing for anemia. The summary measures,

Boutry/Needlman [n18] and CDC, [n17] were also analyzed for their predictive value. To be conservative and err on the side of identifying all possible risk factors, incomplete or don't know responses to individual items were categorized as at risk.

Data analysis used SPSS 8.0 (SPSS, Chicago, IL) and Stat Calc (EpiInfo, CDC, Atlanta, GA). Student's t test was used to compare means of continuous variables

and chi<2> and Fisher's exact test were used for categorical variables. Statistical significance was defined as  $RHO \leq .05$ .

## RESULTS

Of 542 families with eligible children, 342 (63%) enrolled, 131 (24%) refused to participate, and 69 (13%) were missed by recruiters. No statistically significant

differences were noted between enrollees and those who were missed or refused to participate with respect to age, type of insurance, race, gender, and mean lead

and Hb (when available; Table 1). Of enrollees, 282 (82%) had complete blood test sampling and analysis. Laboratory results were incomplete for 60 enrollees; the

cause of incomplete samples included insufficient quantity of blood (37%), unsuccessful venipuncture (32%), clotted CBC (18%), and samples broken or lost in

transport (13%). Enrollees with and without complete laboratory results were not significantly different with respect to mean age, gender, race, health insurance, or

WIC participation. The proportion of at-risk responses to individual questionnaire items was similar for enrollees with and without complete laboratory results. Study

results are reported for the 282 children with complete laboratory results. Of these, 53% were female, 91% were self-reported black, 62% were insured by

medical assistance, 17% were uninsured, 63% received WIC benefits at the time of the survey, and 76% had received WIC in the preceding 12 months.

TABLE 1. Demographic Features of Enrollees and Nonenrollees

| Variable         | Enrollees        |                    | Nonenrollees |
|------------------|------------------|--------------------|--------------|
|                  | Complete Results | Incomplete Results |              |
|                  | n = 282          | n = 60             | n = 200      |
| Mean age mo (SD) | 18.6(6)          |                    |              |

|  |             |              |              |
|--|-------------|--------------|--------------|
|  |             | 18.4(6)      |              |
| % Age <12 mo                                 | 9           |              | 18.0(6)      |
|  |             | 10           |              |
| % Female                                     |             |              | 14           |
|  | 53          |              |              |
|  |             | 47           |              |
| % Black                                      |             |              | 50           |
|  | 91          |              |              |
|  |             | 90           |              |
| % Medical assistance                         |             |              | 90           |
|  | 62          |              |              |
|  |             | 71           |              |
|  |             |              | 65           |
| % Mothers completing form                    |             |              |              |
|  | 85          |              |              |
|  |             | 80           |              |
| % People completing                          |             |              | --           |
|  | 21          |              |              |
|  |             | 18           |              |
|  |             |              | --           |
| form with less than<br>high school education |             |              |              |
| Mean Hb g/dL (SD)                            |             |              |              |
|  | 11.4(1.0)   |              |              |
|  |             | 11.9(1.1) n1 |              |
|  |             |              | 11.2(1.3) n2 |
| Mean lead (SD)                               |             |              |              |
|  | 6.8(4.6) n3 |              |              |
|  |             | 6.6(4.5) n4  |              |
|  |             |              | 6.1(4.1) n5  |

SD indicates standard deviation.

Lead and Hb results were not available for all children.

The denominators used for these calculations are: n1 n = 44, n2 n = 45, n3 n = 179, n4 n = 25, and n5 n = 113.

The prevalence of anemia (IDA + ISA) was 35% in these inner-city, mostly black children. The prevalence of IDA was 8% and the prevalence of IDNA was 7%

(Fig 1). The prevalence of anemia, IDA, and IDNA did not vary by age significantly, by  $\chi^2$  and linear trend analysis. The number of children classified as ID by

the different criteria is presented in Table 2; only 5 children had ID defined by all abnormal laboratory results.

TABLE 2. Number of Iron-Deficient Children by Definition

| Definition           | IDA    | IDNA   |
|----------------------|--------|--------|
|                      | n = 22 | n = 20 |
| Ferritin alone       | 10     | 14     |
| RDW + MCV            | 8      | 5      |
| Ferritin + RDW + MCV | 4      | 1      |

MCV indicates mean corpuscular volume; RDW, red cell distribution width.

The proportion of at-risk responses to individual items varied from 3% to 86%. All children had at least 1 at-risk response and only 3% had fewer than 3 at-risk

responses. The combined proportion of don't know and incomplete responses was 1% to 3% for all individual items except for maternal history items (3%-8%) and

family history of anemia (21%). The sensitivity of individual items for identifying children with IDA was calculated (number of children with IDA whose parent gave

an at-risk response.) Among individual dietary items, drinking >2 glasses of juice per day had the highest sensitivity (77%; 95% confidence interval [CI]: 54,89).

However, because most parents gave an at-risk response to this item but only a few of their children had IDA (most responses were false-positives), the specificity (21%; 95% CI: 17,27) of this item was low. Drinking 3 or more glasses of milk per day was 54% (95% CI: 34,76) sensitive and 56% (95% CI: 51,61) specific for IDA. Children who did not receive WIC benefits were at increased risk for IDA. Overall, only 7 individual questions showed >50% sensitivity for IDA (Table 3).

TABLE 3. Frequency of Risk Response to Individual Items, Domains, and Summary Measures by IDA Status and Corresponding Sensitivity and Specificity

| Questions n2               | IDA           |               |
|----------------------------|---------------|---------------|
|                            | Yes<br>n = 22 | No<br>n = 260 |
|                            | At Risk       | Not At Risk   |
|                            | At Risk       | Not At Risk   |
| Historical domains         |               |               |
| Birth history domain       | 8             | 14            |
| Low birth weight (<2500 g) | 4             | 103           |
| Premature birth (<37 wk)   | 5             | 157           |
| Hospital stay >3 d         | 5             | 18            |
|                            |               | 58            |
|                            |               | 202           |
|                            | 5             | 17            |
|                            |               | 54            |
|                            |               | 206           |
|                            | 5             | 17            |
|                            |               | 65            |

|                                    |    |    |     |
|------------------------------------|----|----|-----|
| Child's health history domain n3   |    |    | 195 |
| Asthma                             | 4  | 18 | 39  |
|                                    |    |    | 221 |
| Eczema                             | 3  | 19 | 29  |
|                                    |    |    | 231 |
| Previous diagnosis of anemia       | 12 | 10 | 52  |
|                                    |    |    | 208 |
| Previous iron therapy              | 11 | 11 | 54  |
|                                    |    |    | 206 |
| Current iron therapy               | 8  | 14 | 32  |
|                                    |    |    | 228 |
| Not entirely well in past month    | 5  | 17 | 84  |
|                                    |    |    | 176 |
| >2 illness/infection visits/3 mo   | 4  | 18 | 32  |
|                                    |    |    | 228 |
| Maternal and family history domain | 14 |    |     |

|                                   |     |     |  |
|-----------------------------------|-----|-----|--|
|                                   | 8   |     |  |
|                                   | 164 |     |  |
|                                   |     | 96  |  |
| n4                                |     |     |  |
| Maternal anemia this pregnancy    | 11  |     |  |
|                                   | 11  |     |  |
|                                   | 111 |     |  |
|                                   |     | 149 |  |
| Maternal anemia other times       | 11  |     |  |
|                                   | 11  |     |  |
|                                   | 105 |     |  |
|                                   |     | 155 |  |
| Mother's third or higher child    | 6   |     |  |
|                                   | 16  |     |  |
|                                   | 73  |     |  |
|                                   |     | 187 |  |
| Other relatives with anemia       | 12  |     |  |
|                                   | 10  |     |  |
|                                   | 131 |     |  |
|                                   |     | 129 |  |
| Dietary domains                   |     |     |  |
| Infant diet domain                | 5   |     |  |
|                                   | 17  |     |  |
|                                   | 53  |     |  |
|                                   |     | 207 |  |
| Mostly low iron formula           | 2   |     |  |
|                                   | 20  |     |  |
|                                   | 32  |     |  |
|                                   |     | 228 |  |
| Mostly breast fed and <2 servings | 3   |     |  |
|                                   | 19  |     |  |

|                                    |    |     |     |
|------------------------------------|----|-----|-----|
|                                    |    | 6   | 254 |
| iron fortified cereal/d at 9 mo    |    |     |     |
| Started cow milk before 1 y of age | 0  |     |     |
|                                    |    | 22  |     |
|                                    |    | 18  |     |
| Toddler beverage intake domain     |    |     | 242 |
|                                    | 20 |     |     |
|                                    |    | 2   |     |
|                                    |    | 224 |     |
| >2 glasses soda/d                  |    |     | 36  |
|                                    | 2  |     |     |
|                                    |    | 20  |     |
|                                    |    | 43  |     |
| >2 glasses juice/d                 |    |     | 217 |
|                                    | 17 |     |     |
|                                    |    | 5   |     |
|                                    |    | 204 |     |
| >3 glasses of cow's milk/d         |    |     | 56  |
|                                    | 12 |     |     |
|                                    |    | 10  |     |
|                                    |    | 115 |     |
| Toddler solid food intake domain   |    |     | 145 |
|                                    | 20 |     |     |
|                                    |    | 2   |     |
|                                    |    | 185 |     |
| <5 servings/wk of bread or cereal  |    |     | 75  |
|                                    | 8  |     |     |
|                                    |    | 14  |     |
|                                    |    | 51  |     |
|                                    |    |     | 209 |

|                                    |    |    |     |     |
|------------------------------------|----|----|-----|-----|
| <5 servings/wk of fruits           | 10 | 12 | 64  | 196 |
| <5 servings/wk of vegetables       | 5  | 17 | 44  | 216 |
| <5 servings/wk of meat or beans    | 9  | 13 | 71  | 189 |
| Eat chips, snacks, sweets daily    | 11 | 11 | 109 | 151 |
| Does not take multivitamin daily   | 15 | 7  | 229 | 31  |
| WIC participation domain           | 14 | 8  | 105 | 155 |
| Not currently receiving WIC        | 12 | 10 | 91  | 169 |
| benefits                           |    |    |     |     |
| Has not received WIC in past 12 mo | 11 |    |     |     |

|                  |    |    |     |     |
|------------------|----|----|-----|-----|
|                  |    | 11 |     |     |
|                  |    |    | 57  |     |
|                  |    |    |     | 203 |
| Summary measures |    |    |     |     |
| Boutry/Needlman  |    |    |     |     |
|                  | 21 |    |     |     |
|                  |    | 1  |     |     |
|                  |    |    | 221 |     |
|                  |    |    |     | 39  |
| CDC              |    |    |     |     |
|                  | 16 |    |     |     |
|                  |    | 6  |     |     |
|                  |    |    | 184 |     |
|                  |    |    |     | 76  |

Questions n2

Percentage  
Sensitivity  
Specificity

n1

Historical domains

Birth history domain

--

--

Low birth weight (<2500 g)

--

--

Premature birth (<37 wk)

--

--

Hospital stay >3 d

--

--

Child's health history domain n3

Asthma

--

--

Eczema

|                                    |    |    |
|------------------------------------|----|----|
|                                    | -- | -- |
| Previous diagnosis of anemia       | 54 | 80 |
| Previous iron therapy              | 50 | 79 |
| Current iron therapy               | -- | -- |
| Not entirely well in past month    | -- | -- |
| >2 illness/infection visits/3 mo   | -- | -- |
| Maternal and family history domain | 64 | 37 |
| n4                                 |    |    |
| Maternal anemia this pregnancy     | 50 | 57 |
| Maternal anemia other times        | 50 | 60 |
| Mother's third or higher child     | -- | -- |
| Other relatives with anemia        | 54 | 50 |
| Dietary domains                    |    |    |
| Infant diet domain                 | -- | -- |
| Mostly low iron formula            |    |    |

|                                    |    |    |
|------------------------------------|----|----|
|                                    | -- | -- |
| Mostly breast fed and <2 servings  | -- | -- |
|                                    | -- | -- |
| iron fortified cereal/d at 9 mo    |    |    |
| Started cow milk before 1 y of age | -- | -- |
|                                    | -- | -- |
| Toddler beverage intake domain     | 91 |    |
|                                    |    | 14 |
| >2 glasses soda/d                  | -- | -- |
|                                    | -- | -- |
| >2 glasses juice/d                 | 77 |    |
|                                    |    | 22 |
| >3 glasses of cow's milk/d         | 54 |    |
|                                    |    | 56 |
| Toddler solid food intake domain   | 91 |    |
|                                    |    | 29 |
| <5 servings/wk of bread or cereal  | -- | -- |
|                                    | -- | -- |
| <5 servings/wk of fruits           | -- | -- |
|                                    | -- | -- |
| <5 servings/wk of vegetables       | -- | -- |
|                                    | -- | -- |
| <5 servings/wk of meat or beans    | -- | -- |
|                                    | -- | -- |
| Eat chips, snacks, sweets daily    |    |    |

|                                    |    |    |
|------------------------------------|----|----|
|                                    | 50 |    |
|                                    |    | 58 |
| Does not take multivitamin daily   | 68 |    |
|                                    |    | 12 |
| WIC participation domain           | 64 |    |
|                                    |    | 60 |
| Not currently receiving WIC        | 54 |    |
|                                    |    | 65 |
| benefits                           |    |    |
| Has not received WIC in past 12 mo | 50 |    |
|                                    |    | 78 |
| Summary measures                   |    |    |
| Boutry/Needlman                    | 95 |    |
|                                    |    | 15 |
| CDC                                | 73 |    |
|                                    |    | 29 |

n1 Only sensitivity  $\geq 50\%$  presented in table.

n2 For domain risks, 1 at-risk response within the domain resulted in at-risk classification.

n3 Child's health history domain risk not generated.

n4 Includes 3 maternal history items but not family history of anemia item.

For each questionnaire domain, any 1 at-risk response within the domain resulted in the child being classified as at risk. Domains with highest sensitivity for IDA were beverage intake (91%; 95% CI: 68,99) and solid food intake (91%; 95% CI: 68,99) with specificities of 14% and 29%, respectively. Absence of current and past WIC participation was 64% (95% CI: 40,83) sensitive and 60% (95% CI: 55,65) specific. Overall, domains with high sensitivity had low specificity for IDA (Table 3).

The Boutry/Needlman summary measure was 95% (95% CI: 77,99) sensitive for IDA but only 15% (95% CI: 11,19) specific. The CDC summary measure was 73% (95% CI: 56,92) sensitive and 29% (95% CI: 24,35) specific for IDA (Table 3).

In additional analyses, individual questions, domains of questions, and summary measures were found to have similar sensitivity and specificity for anemia and ID

(IDA + IDNA) as reported for IDA. The individual item, domain, and summary measure analyses were repeated on subgroups of children by age: <15 months and

<18 months of age. The results were similar. Logistic regression models were developed to determine whether any other group of questions was predictive of IDA.

Models explored included all questions, dietary questions, health history questions, and selected groups from both categories. No models were identified that were

more sensitive than that proposed by Boutry and Needlman. [n18]

Because serum ferritin is also an acute phase reactant that can temporarily increase in the face of even mild infection, we reviewed the data for possible

misclassification of children as ISA rather than IDA. There were 21 children who were classified as ISA and whose parent answered no to the question: "Has your

child been entirely well in the past month?" Assuming that children with true IDA would have at least a low mean corpuscular volume or an elevated red cell

distribution width, we identified 7 children who possibly could have been classified as ISA rather than IDA based on ferritin level. We reclassified these 7 children

as IDA and repeated the analyses. The sensitivity and specificity of individual items, domains of items, and summary measures for IDA did not change >5% with these children reclassified.

## DISCUSSION

The 8% prevalence of IDA and the 7% prevalence of IDNA in this study population demonstrated that ID is still a significant problem for poor, minority children

and is consistent with the findings of Eden and Mir. [n12] However, the 35% prevalence of anemia was nearly twice the rate recently reported for the WIC

population [n20] and may reflect the primarily black study population. Nonetheless, less than one quarter of these anemic children had ID as the cause. The 7% of

children in the study with IDNA would be missed and the 27% with ISA would be unnecessarily treated with iron by current blood test screening using Hb or hematocrit.

Individual items and domains of items were neither adequately sensitive to identify at least 95% of children with IDA nor sufficiently specific to eliminate at least half

of children from blood test screening for IDA. Although the Boutry/Needlman summary measure identified 21 of 22 subjects with IDA (95% sensitive), it also

identified 221 of 260 subjects without IDA (15% specific), thereby failing the function of a first-stage screen to reduce the number of subjects needed to undergo subsequent screening phases. In this population, the positive predictive value of the Boutry/Needlman summary measure was 9% and the negative predictive value was 98%.

This study had potential limitations associated with the accessible population, study sample size, lack of a gold standard for IDA, and questions used in the instrument. First, the study population was nearly all black and, therefore, not representative of low-risk populations for whom the use of dietary and health history is currently advocated. However, because the predictive value of a screening test depends on the prevalence of the disease in the population being screened, the study questionnaire would be expected to have even lower predictive value in a low-risk population. Second, based on an estimated 10% prevalence of IDA in this population, we originally calculated that 730 children would need to be enrolled to allow construction of a 95% CI of  $\pm 5\%$  around a point estimate of 95% for the questionnaire's sensitivity as a predictor of IDA. Given our sample size of 282, we are similar to 70% confident that the results lie within a 5% range of the calculated sensitivities and 85% confident that the results lie within a 5% range of calculated specificities. The limited sample resulted in wider than desired confidence intervals for the test parameters and limited the exploratory subgroup analyses by age and severity of anemia. However, it does not change the conclusions of the study. Although there is no gold standard for diagnosing IDA, a response to iron therapy is still probably the best available test. Because the cross-sectional design of this study was not compatible with this approach, we chose the approach used in the National Health and Nutrition Examination Survey, which is to use multiple laboratory tests to define iron status. Finally, although the study questions concerned commonly acknowledged risk factors, there may be other questions that are more predictive of IDA that were not included in the study instrument. It may be possible to develop a more specific screening tool by targeting a smaller age range, for example, 9 to 12 months old, where the diet is less variable, though this may not be the age group at greatest risk.

IDA remains prevalent among inner-city black children. The study findings suggest that the use of dietary and health history as the first step in a 2-stage screening for IDA would not be effective. Additional investigation is needed to determine the most effective method to screen for IDA and IDNA in various populations.

Because the ultimate goal of screening is to identify children before they become overtly anemic, it may be more appropriate to use an albeit more expensive but definitive blood test for iron status rather than using dietary and health history and/or Hb testing, especially in high-risk populations.

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SUPPLEMENTARY INFORMATION: From the <1> Department of Pediatrics, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania; and <2> Department of Pediatrics, Johns Hopkins University School of Medicine, Baltimore, Maryland.

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Reprint requests to (D.L.B.) General Academic Pediatrics, Children's Hospital of Pittsburgh, 3705 Fifth Ave, DeSoto G-205, Pittsburgh, PA 15213. E-mail: bogend@chplink.chp.edu

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GRAPHIC: Figure 1, Percent distribution of participant iron status by age.