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CENTER FOR DISEASE CONTROL

NUTRITION SURVEILLANCE

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

PREFACE

This report summarizes information, including selected indices of nutrition status, received from 11 participating states which comprise a group of contributors to a developing program of nutrition surveillance in the United States. We will consider adding other indices as their utility and availability become evident. To the extent possible, tabulations in subsequent issues will be presented in the same format unless experience indicates a change is appropriate.

The data presented in these tabulations come from a variety of sources including health department clinics, WIC screening, Head-start programs, and other health care situations. Because of the lack of uniformity of data sources, as well as methodology, direct comparisons among states should be made with caution.

Contributions to NUTRITION SURVEILLANCE are welcome. Please submit to:

Center for Disease Control
Attention: Nutrition Division, BSE
Atlanta, Georgia 30333

Center for Disease Control . . . . .William H. Foege, M.D.
Director

NUTRITION INDICES

Data presented in Tables 1-3 represent children examined during the first quarter of 1977. They reflect initial visits to the health system and do not represent either the results of nutrition intervention or the nutritional status of the general population.

CRITERIA FOR IDENTIFYING INDIVIDUALS WITH LOW OR HIGH VALUES

1. Low Hemoglobin and Low Hematocrit: Hemoglobin or hematocrit below the level specified in the following table for appropriate age and sex.

Age	Hgb.	Hct.
6-23 months	10 grams	31%
2-5 years	11 grams	34%
6-14 years	12 grams	37%
15 or more years (females)	12 grams	37%
15 or more years (males)	13 grams	40%

2. Low Height-for-Age: Height-for-age less than the 5th percentile of a person of the same sex and age in the reference population.

3. Low Weight-for-Age: Weight-for-age less than the 5th percentile of a person of the same sex and age in the reference population.

4. Low Weight-for-Height: Weight-for-height less than the 5th percentile of a person of the same sex and height in the reference population.

5. High Weight-for-Height: Weight-for-height greater than the 95th percentile of a person of the same sex and height in the reference population.

Reference Population: Smoothed distribution of percentiles of the following populations:

Age	Reference Population Data
Birth - 24 months	Fels Research Institute Growth Study
25 - 59 months	First Health and Nutrition Examination Survey (HANES)
60 - 143 months	National Health Examination Survey, Cycle II; and HANES
144 - 215 months	National Health Examination Survey, Cycle III; and HANES

Note: Growth percentiles represent heights and weights which have been standardized for sex and age, and sex and height (for weight-for-height). Therefore height and weight comparisons may be made between groups of individuals using percentiles without being concerned about the age and sex distributions of groups being compared. However, comparisons of height and weight among groups with persons of diverse ethnic origins should be made with care because of possible genetic differences in growth potential. Differences observed between groups may be due to differences in nutritional status of the individuals or in possible differences in the ethnic makeup of the groups.

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Table 1

Nutrition Indices by State, January-March 1977
Persons Less than 18 Years of Age

State	Hemoglobin		Hematocrit		Height-For-Age		Weight-For-Age		Weight-For-Height		
	No. Exam.	% Low	No. Exam.	% Low	No. Exam.	% Low	No. Exam.	% Low	No. Exam.	% Low	% High
Arizona	1,657	6.4	2,453	16.9	4,536	16.4	4,489	10.0	3,159	5.8	13.7
California (Los Angeles County)	77	3.9	140	20.0	272	11.8	273	7.3	197	2.5	15.7
Florida	12	0.0	34	20.6	243	9.1	290	6.6	158	6.3	9.5
Kentucky	1,970	19.9	1,924	21.9	5,968	12.8	5,977	6.5	4,632	5.9	13.0
Louisiana	2,863	17.4	1,501	20.4	5,254	10.4	5,327	6.5	3,324	4.7	10.4
Montana	8	12.5	561	21.9	955	15.3	963	6.3	781	2.3	8.5
Nevada	96	7.3	84	14.3	257	10.9	260	8.8	230	8.3	8.3
Ohio	449	3.8	733	15.6	1,669	8.0	1,676	5.0	1,261	4.9	8.2
Oregon	336	16.4	416	10.6	1,241	13.2	1,241	8.2	1,047	4.9	9.6
Tennessee	215	4.7	8,234	24.6	10,499	11.5	10,550	5.4	8,358	3.5	13.3
Washington	192	15.1	1,845	12.7	2,786	12.1	2,793	5.9	2,389	3.1	14.7
Total	7,875	14.2	17,925	20.8	33,680	12.3	33,839	6.6	25,536	4.5	12.5

Table 2

Nutrition Indices by Sex and Ethnic Group, January-March 1977
Persons Less than 18 Years of Age

Sex and Ethnic Group	Hemoglobin No. Exam.	Hemoglobin % Low	Hematocrit No. Exam.	Hematocrit % Low	Height-For-Age No. Exam.	Height-For-Age % Low	Weight-For-Age No. Exam.	Weight-For-Age % Low	Weight-For-Height No. Exam.	Weight-For-Height % Low	Weight-For-Height % High
Male											
Black	1,345	17.2	2,009	26.2	4,291	12.5	4,344	6.3	3,075	4.4	11.1
White	1,948	14.7	5,636	19.8	10,136	12.5	10,163	6.5	8,436	4.3	12.3
Sp. American	422	7.8	571	18.0	1,068	15.4	1,060	7.7	841	4.3	11.9
Am. Indian	73	4.1	502	23.3	1,011	20.0	997	9.7	758	7.3	19.4
Oriental	12	8.3	31	9.7	55	18.2	55	10.9	52	3.8	5.8
Other	13	0.0	59	23.7	84	23.8	85	25.9	75	8.0	12.0
Unknown	16	12.5	67	13.4	97	10.3	98	4.1	86	2.3	9.3
Total	3,829	14.5	8,875	21.3	16,742	13.2	16,802	6.8	13,323	4.5	12.4
Female											
Black	1,441	17.5	2,124	24.0	4,548	10.3	4,597	5.9	2,850	4.5	11.3
White	2,030	13.0	5,630	19.4	10,080	11.0	10,132	6.0	7,744	4.4	12.2
Sp. American	455	8.8	616	14.8	1,097	14.6	1,099	8.1	757	2.9	12.7
Am. Indian	76	1.3	521	23.6	1,005	16.0	998	8.7	695	5.5	21.9
Oriental	13	23.1	27	7.4	51	9.8	51	7.8	45	8.9	8.9
Other	11	18.2	36	19.4	61	13.1	63	9.5	51	7.8	13.7
Unknown	16	12.5	62	16.1	96	13.5	97	15.5	71	5.6	8.5
Total	4,042	13.9	9,016	20.3	16,938	11.4	17,037	6.3	12,213	4.4	12.6

Table 3

Nutrition Indices by Sex and Age, January-March 1977
Persons Less than 18 Years of Age

Sex and Age Group	Hemoglobin No. Exam.	Hemoglobin % Low	Hematocrit No. Exam.	Hematocrit % Low	Height-For-Age No. Exam.	Height-For-Age % Low	Weight-For-Age No. Exam.	Weight-For-Age % Low	Weight-For-Height No. Exam.	Weight-For-Height % Low	Weight-For-Height % High
Male											
<1	526	7.8	1,319	10.4	6,320	15.3	6,345	7.0	4,399	6.0	12.6
1	752	13.3	1,850	13.1	2,498	15.5	2,516	8.3	2,461	5.2	16.1
2-5	1,521	16.2	3,755	26.0	5,027	11.6	5,038	6.5	4,972	3.2	12.0
6-9	417	18.5	864	36.3	1,214	7.2	1,217	3.9	1,179	3.6	6.7
10-12	271	12.9	524	26.1	767	9.8	767	5.9	312	3.5	6.4
13-17	342	16.7	563	14.6	916	11.4	919	8.2	-	-	-
Total	3,829	14.5	8,875	21.3	16,742	13.2	16,802	6.8	13,323	4.5	12.4
Female											
<1	528	6.3	1,291	10.2	6,166	12.7	6,207	6.5	4,048	5.3	12.4
1	692	13.2	1,731	12.2	2,321	13.3	2,341	6.7	2,290	4.0	17.0
2-5	1,437	14.7	3,611	23.6	4,828	11.5	4,846	6.9	4,779	3.9	12.0
6-9	438	18.3	891	32.7	1,257	7.3	1,261	5.4	1,087	4.6	6.3
10-12	317	12.6	569	22.5	871	8.6	872	5.8	9	0.0	11.1
13-17	630	17.1	923	23.6	1,495	7.4	1,510	4.0	-	-	-
Total	4,042	13.9	9,016	20.3	16,938	11.4	17,037	6.3	12,213	4.4	12.6

SPECIAL REPORT

THE RELATIONSHIP BETWEEN HEMOGLOBIN AND HEMATOCRIT VALUES

It is sometimes assumed that hemoglobin (Hgb) and hematocrit (Hct) determinations are, for practical purposes, equally useful in detecting anemia, and can thus be employed interchangeably as screening tests. This tacit assumption is supported by the fact that nutrition surveillance cut-off levels, for various age and sex subgroups, equate the following values of Hgb and Hct: 10g/100 ml and 31%, 11 and 34, 12 and 37, and 13 and 40; a fixed relationship described by the equation, Hct = (3xHgb) + 1.

That these two different hematologic measures do not in fact classify individuals in the population in the same way is clear. With the above cut-off levels, the experience of nutrition surveillance has been that, compared with the prevalence of anemia by Hgb determination, the prevalence of anemia by Hct is either higher or lower by 5 to 30, depending upon age. Typically in the age group 6 months to 2 years there is a higher prevalence of anemia based on Hgb determinations. A portion of this observed difference in prevalence is undoubtedly due to differences in methodology and accuracy of the hematologic determinations in the various states, and also to the fact that in most areas both tests are not performed on the same individuals. In the HANES survey, however, in which systematic quality control was practiced and in which Hgb and Hct were determined on the same persons, an even higher relative prevalence of low Hgb values was observed, almost 3 times that observed for low Hct values in the 1-2 year-old age group.

In considering how accurately a screening test will identify persons with an abnormal condition in a given population, it is necessary to consider three factors: the sensitivity and specificity of the test, and the prevalence of the condition in that population. A test's sensitivity is defined as the proportion of all persons with the condition who are screened positive, and its specificity, as the proportion of all persons without the condition who are screened negative. The higher the sensitivity, the lower will be the false negative rate, but this is generally achieved at the expense of lower specificity, along with more false positives, and vice-versa.

At a given cut-off level, a screening test's sensitivity and specificity remain fixed, whatever the level of prevalence of the condition in the population. In order to measure the test's real efficiency in correctly classifying persons with and without the condition, an estimate of the condition's prevalence is required. With such an estimate, a third index, the predictive value of a positive test, can be determined. This index is defined as the proportion of all persons screened positive who actually have the condition. Unlike the indices of sensitivity and specificity, the predictive value varies with prevalence; at any level of sensitivity or specificity, the lower the prevalence, the lower will be the predictive value of a positive test, and vice-versa. Even a test of very high sensitivity and specificity will have poor predictive value for detecting a condition which is very rare in the population. Conversely, a test with only moderate sensitivity or specificity may have a satisfactory predictive value for a condition which is common.

With this background, several observations on the utility of Hct as a screening test, in relation to Hgb as a definitive test for anemia will be presented. In this exercise, data for children 6 months through 1 year of age will be examined, and Hgb values below 10g/100 ml will be considered synonymous with anemia. In reality, it is clear that, due to the broad and overlapping distributions of Hgb values in populations of anemic and non-anemic persons, this cut-off level results in inevitable misclassifications. Some non-anemic children will have values <10g/100 ml and will falsely be labeled as positive, while some of the truly anemic children, with values of 10g/100 ml or greater, will be false negatives. To detect iron deficiency, the probable cause of anemia in most children, it would be necessary to repeat the Hgb determination after a course of supplemental iron, or to perform transferrin saturation, "free" erythrocyte protoporphyrin, or serum ferritin determinations.

For purposes of this discussion, the 10g/100 ml cutoff for Hgb will be assumed to divide the children correctly into anemic and non-anemic groups, and the sensitivity, specificity and predictive value of Hct in identifying these groups will be examined. Two sets of data will be used, one from the Ten-State Survey for Black children 6 months to 2 years old, and the other, from the HANES Survey, for White children 1 to 2 years old:

Table 1
Sensitivity and Specificity of Hematocrit Levels <31 Percent
in Identifying Children with Hemoglobin Levels <10g/100 ml
(Blacks, Age 6-24 Months, Ten-State Nutrition Survey)

Hematocrit Levels	Hemoglobin Levels - ("True" Condition)		
(Screening Test)	<10g/100 ml	10g/100 ml +	Total
<31%	37	9	46
31% +	56	159	215
Total	93	168	261

Sensitivity:	37/93	= 39.8%
Specificity:	159/168	= 94.6%
False Negative:	56/93	= 60.2%
False Positive:	9/168	= 5.4%
Prevalence of Low Hemoglobin:	93/261	= 35.6%
Predictive Value of Positive Screening Test:	37/46	= 80.4%

Table 2
Sensitivity and Specificity of Hematocrit Levels <31 Percent in Identifying Children with Hemoglobin Levels <10g/100 ml (Whites, Age 12-24 Months, HANES I)

Hematocrit Levels (Screening Test)	Hemoglobin Levels - ("True" Condition) <10g/100 ml	10g/100 ml +	Total
<31%	11	1	12
31 +	22	248	270
Total	33	249	282

Sensitivity: 11/33 = 33.3%
Specificity: 248/249 = 99.6%
False Negative: 22/33 = 66.7%
False Positive: 1/249 = 0.4%
Prevalence of Low Hemoglobin: 33/282 = 11.7%
Predictive Value of Positive Screening Test: 11/12 = 91.7%

It is evident that for the HANES data the sensitivity of Hct as a screening test is somewhat less, and the specificity is greater than for the Ten-State data. In the HANES data the prevalence of low Hgb values is much lower than in the Ten-State data, while the predictive values of a positive test, due to the now nearly 100 percent level of specificity, is considerably greater. In these two data sets the prevalence of low Hct values is less than half that for low Hgb values.

It is instructive to look again at the Ten-State data, maintaining the same sensitivity and specificity values but assuming the same prevalence of low Hgb values as that for HANES data; approximately 12 percent.

Table 3
Sensitivity and Specificity of Hematocrit Levels <31 Percent in Identifying Children with Hemoglobin Levels <10g/100 ml (Blacks, Age 6-24 Months, Ten-State Nutrition Survey, Assuming A Lower Prevalence Rate)

Hematocrit Levels (Screening Test)	Hemoglobin Levels - ("True" Condition) <10g/100 ml	10g/100 ml +	Total
<31%	12	12	24
31% +	19	218	237
Total	31	230	261

Sensitivity: 12/31 = 38.7%
Specificity: 218/230 = 94.8%
False Negative: 19/31 = 61.3%
False Positive: 12/230 = 5.2%
Prevalence of Low Hemoglobin: 31/261 = 11.9%
Predictive Value of Positive Screening Test: 12/24 = 50%

Compared with the actual Ten-State data, the sensitivity is now slightly lower and, the specificity very slightly higher, but the predictive value is markedly lower, down from 80 percent to 50 percent. If the false positive rate is redefined as the proportion of all persons with positive tests who are false positives, rather than the proportion of all persons without anemia who are false positives, this version of the false positive rate becomes 12/24 = 50 percent, 10 times higher than the standard false positive rate. This redefined rate, the complement of the predictive value of a positive test, is for certain purposes, a more realistic and useful index of a screening test's efficiency.

Finally the Ten-State data is represented to illustrate the effect of raising the cutoff level of the screening test from 31 to 32 percent. The prevalence of low Hgb values remains unchanged from the actual value.

Table 4
Sensitivity and Specificity of Hematocrit Levels <32 Percent in Identifying Children with Hemoglobin Levels <10g/100 ml (Blacks, Age 6-24 Months, Ten-State Nutrition Survey, Actual Prevalence Rate)

Hematocrit Levels (Screening Test)	Hemoglobin Levels - ("True" Condition)		
	<10g/100 ml	10g/100 ml +	Total
<32%	49	16	65
32% +	44	152	196
Total	93	168	261

Sensitivity:	49/93	= 52.7%
Specificity:	152/168	= 90.5%
False Negative:	44/93	= 47.3%
False Positive:	16/168	= 9.5%
Prevalence of Low Hemoglobin:	93/261	= 35.6%
Predictive Value of Positive Screening Test:	49/65	= 75.4%

By thus elevating the Hct cutoff, the sensitivity of Hct as a screening test becomes considerably greater, but the specificity, considerably less. The predictive value of a positive test is now somewhat lower, but still at a level so that only one out of four persons screened as positive is falsely positive. The screened positive rate goes up from 17.6 percent (46/261) to 24.9 percent (65/261), a rate still much lower than that for low Hgb values 35.6 percent (93/261; "true" prevalence).

By further elevating the Hct cutoff to 34 percent, sensitivity becomes 81.7 percent, specificity, 72.6 percent and predictive value, 62.3 percent. At this screening level, the screened positive rate becomes higher than the true prevalence rate, 46.7 percent vs 35.6 percent.

These data suggest strongly that one cannot simply substitute hematocrit for hemoglobin determinations in the process of screening children for the presence of possible anemia. Under ideal conditions either a positive hemoglobin or hematocrit should be followed up by repeat determinations including hematologic indices to determine whether or not anemia is in fact present. However, given the logistics and number of children involved, it is clear that the initial screening test is used in many situations as a diagnostic test prior to an initial course of therapy, or referral. It is evident from the literature that hemoglobin determinations, by the cyanmethemoglobin method, are the screening method of choice in assessing the prevalence of anemia. (Reference WHO Publication on Anemia) In situations where both hemoglobin and hematocrit determinations are performed on the same children and where the opportunity for repeat determinations prior to the institution of primary therapy is not possible, we would recommend that referrals for therapy be based on hemoglobin levels. Additional help in evaluation may be derived by calculating mean corpuscular hemoglobin concentration (MCHC) values (Hgb in g per 100 ml/Hct in percent). Ideally, however, such children should be referred for more detailed hematologic evaluation prior to the initiation of therapy. In those situations where a nutrition screening program is being instituted or where the possibility exists for upgrading methodology, we would highly recommend the institution of hemoglobin determinations by the cyanmethemoglobin method as the single screening method for anemia rather than the use of hematocrit determinations.