Suggested sex and age appropriate values for "low" and "deficient" hemoglobin levels[1-4]

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ABSTRACT New values for "deficient" and "low" Hb have been calculated as the smoothed 5th and the 15th percentiles for white males and females included in the National Health and Nutrition Examination Survey (NHANES I). With separate tabulations for 18,389 white individuals contained in this data base and for 12,320 with transferrin saturation values of 16% and above, these new values have the advantage of being fully age-specific, based upon a single source of hematological data and providing quantitative definitions of "low" and "deficient." *Am. J. Clin. Nutr.* 34: 1648–1651, 1981.

KEY WORDS Hemoglobin, standard values, low, deficient, hematologic norms, nutrition surveys

Those of us who have attempted to make use of hematological "standards" in the analysis of nutrition survey data have encountered numerous problems. Values defined as "low," "deficient", or "probably abnormal" in various texts and manuals have often differed from text to text. Broad age groupings commonly given have provided difficulties in survey data analysis. Moreover, appropriate Hb and hematocrit (Hct) values for older adults have proved nonexistent (1–6). When we attempted to track such textbook values to their sources, we discovered that supporting data were lacking in most cases, and that they existed only for a few age groups at best. In no textbook example were the terms "low" or "deficient" or "abnormal" afforded quantification, such that the proportion of individuals deemed "low" or "deficient" in a survey population could be compared with expectancy.

Accordingly, we endeavored to find a source of Hb data that would have the following characteristics. First it would come from a single source, covering the broad age range from early infancy through the 8th decade. Second, it would approximate a National Probability Sample or at least not be poverty oriented. Third, it would contain sufficient numbers of subjects at each age level to allow the calculation of the lower percentiles (p = 15 and p = 5). Fourth, it would contain additional data on socioeconomic status (SES) and on transferrin saturation values, both of concern to workers in clinical nutrition.

Hemoglobin data from the National Health and Nutrition Examination Survey (NHANES I) (7) met these four criteria for white individuals, with an N in excess of 18,000. However, subject Ns were insufficient for comparable data reduction and tabulation of 3851 black participants in NHANES I.

Using the data tape DU 48 0010, we calculated the 5th and 15th percentiles for Hb in NHANES I by 1 yr (midpoint) age groups through age 17 and for decade groupings thereafter, through midpoint age 70. The 5th percentile cutoff value we defined as "defi-

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cient." The 15th percentile (approximating the −1 SD limit) was here defined as "low." Separate 5th and 15th percentile calculations were made *1*) for all 18,389 individuals with available Hb data and *2*) for 12,320 NHANES I participants with serum transferrin saturation values (percentage saturation) above 16%. Finally, 5 point smoothing was used to minimize effects of sampling fluctuations (8).

The results of these successive steps in data reduction, data analysis, and smoothing are given in **Table 1**. Fifth, 15th and 50th percentile values for 18,389 NHANES I white participants are shown on the left under the heading "All transferrin saturation levels." Corresponding hemoglobin values for 13,320 white participants with transferrin saturation values of 16% and above are shown on the right of Table 1.

It is of interest to note that the exclusion of low serum transferrin saturation levels (≤16%) does reduce the subject N considerably, especially for the infant years. Such exclusion, however, does little to affect the hemoglobin percentiles, both those designated as "low" (p = 15) and "deficient" (p = 5) and especially after the 1st or 2nd yr. A largely nonsystematic difference averaging less than 0.01 g/dl is observed overall. In view of this fact, the Hb percentile values for the total sample may be the more useful as standards or standard values.

Comparison with an "advance" publication from the NHANES I data shows that these newly calculated percentiles are in good agreement with the earlier report, taking into account the broader age categories used in that analysis (7). Comparison with Hb percentiles from the Ten-State Nutrition Survey of 1968 to 1970 previously calculated by us, show that the NHANES I percentiles (5th, 15th, and 50th) tend to be somewhat higher by about 0.5 g/dl overall.

In view of this fact, we also explored the extent of socioeconomic influence on the Hb percentiles in NHANES I. To do this we calculated Hb percentiles for the higher in-

TABLE 1
Smoothed percentiles for Hb in American whites including values defined as "low" and "deficient"

Age mid-point	All transferrin saturation level								Excluding low transferrin saturations							
	Males				Females				Males				Females			
	n	p = 5*	p = 15*	p = 50	n	p = 5	p = 15	p = 50	n	p = 5	p = 15	p = 50	n	p = 5	p = 15	p = 50
1	199	9.8†	11.0†	12.1†	179	9.7†	11.0†	12.0†	42	11.2†	11.4†	12.3†	34	11.0†	11.4†	12.2†
2	205	10.7†	11.2†	12.5†	197	10.6†	11.1†	12.6†	72	11.1†	11.5†	12.7†	74	10.9†	11.6†	12.6†
3	220	11.1	11.5	12.6	204	10.8	11.3	12.5	101	11.2	11.7	12.6	98	11.0	11.6	12.6
4	222	11.3	11.7	12.6	199	11.0	11.7	12.6	172	10.2	11.7	12.7	148	11.2	11.8	12.7
5	197	11.3	11.9	12.8	219	11.1	11.8	12.7	138	11.2	11.9	12.8	167	11.4	11.9	12.9
6	119	11.6	12.1	13.0	117	11.4	11.9	12.9	93	11.2	12.0	13.1	82	11.5	12.0	13.1
7	123	11.8	12.2	13.3	115	11.5	11.9	13.0	102	11.8	12.3	13.2	94	11.6	12.0	13.1
8	115	12.0	12.4	13.3	112	11.7	12.2	13.3	85	12.1	12.5	13.4	78	11.7	12.1	13.2
9	114	11.9	12.5	13.3	125	11.9	12.3	13.3	90	12.0	12.5	13.4	107	11.8	12.3	13.3
10	140	11.9	12.6	13.4	146	12.0	12.5	13.3	103	12.0	12.5	13.5	128	11.9	12.6	13.4
11	123	11.9	12.7	13.5	119	12.1	12.6	13.6	101	12.0	12.7	13.6	97	12.0	12.7	13.6
12	145	12.2	12.9	13.8	123	12.1	12.6	13.6	127	12.2	13.0	13.8	108	12.1	12.7	13.7
13	122	12.5	13.1	14.1	147	12.2	12.6	13.6	103	12.6	13.2	14.1	117	12.2	12.8	13.7
14	129	12.9	13.4	14.7	131	12.2	12.6	13.6	111	13.1	13.5	14.5	98	12.3	12.8	13.8
15	118	13.2	13.7	14.9	122	12.1	12.6	13.7	96	13.3	13.8	15.0	88	12.2	12.8	14.0
16	124	13.5	14.0	15.3	134	12.0	12.6	13.7	108	13.6	14.2	15.4	105	12.1	12.7	14.0
17	131	13.8	14.4	15.7	108	12.0	12.6	13.7	112	13.9	14.4	15.7	86	12.1	12.7	13.8
20	457	14.0	14.7	15.8	730	12.1	12.6	13.7	406	14.0	14.6	15.8	592	12.2	12.7	13.8
30	1084	14.0	14.7	15.7	2303	12.0	12.7	13.6	698	14.0	14.7	15.8	1469	12.3	12.8	13.8
40	778	13.9	14.6	15.6	1559	11.9	12.6	13.7	498	14.0	14.7	15.7	939	12.3	12.9	13.9
50	872	13.7	14.4	15.5	1012	12.0	12.7	13.8	522	13.9	14.6	15.7	551	12.4	13.0	14.0
60	719	13.4†	14.2†	15.4†	791	12.3†	12.8†	14.0†	411	13.5†	14.2†	15.6†	453	12.4†	13.0†	14.2†
70	1445	13.2†	14.0†	15.4†	1596	12.1†	12.7†	14.0†	1116	13.3†	14.1†	15.4†	1200	12.3†	12.9†	14.1†

* "Deficient" (p = 5) and "low" (p = 15), respectively.
† Unsmoothed (see text), all other values involve 5-point smoothing (8).

come participants (p = 85 and above for total family income) and for the lower income NHANES I participants (p = 15 and below for family income). Separate cutoff values were used for children age 17 and below and for adults. This comparison by family income showed no systematic income effect on Hb, with differences averaging no more than 0.01 g/dl overall. Accordingly, age-to-age fluctuations in per capita income present in the NHANES I data do not systematically bias the results. Since the data were analyzed age by age, deliberate "oversampling" is again without effect on the results.

Since some of our correspondents expressed an interest in SDs for Hb, we also calculated this statistical measure, at each of the ages given in Table 1. It was immediately apparent that values of sigma (i.e., σ or the SD) closely corresponded to the difference between the 15th and the 50th percentile, within limits set by rounding off. From abbreviated results given in **Table 2**, it is obvious that the HANES hemoglobin data are reasonably free from skewness. Potential users may profitably employ the difference between the 15th and 50th percentiles (p = 50 to p = 15) as given in Table 1 in lieu of sigma, independently calculated.

TABLE 2
Actual and estimated SDs for Hb (d/dl) at selected ages

Age	SD (males)		SD (females)	
	Actual	Estimated*	Actual	Estimated*
3	1.1	1.1	1.1	1.2
4	.9	.9	1.0	.9
12	1.0	.9	1.0	1.0
30	1.1	1.0	1.1	.9
70	1.3	1.4	1.2	1.3

* i.e., p = 50 to p = 15 (from Table 1).

When the percentile values here designated as "deficient" are compared with values designated as deficient, unsatisfactory or "below the normal range" in the literature, the problem of broad age categories commonly given complicates comparisons. Nevertheless, and using selected values from Table 1, it is obvious that such textbook values generally fall below the 5th percentile for NHANES I, often by 1 g/dl and in some cases by 2 g/dl and more. By way of example, the "adult" values most commonly given in the United States fall a full 2 g/dl below the corresponding sex-appropriate 5th percentile value from NHANES I. In addition, as may be seen in the comparison given in **Table 3**, the newly developed values for older individuals have no correspondences in the literature.

While it is not our intention to discuss substantive hematological findings in this short communication, three observations on age trends in Hb deserve comment. The first has to do with the marked age-associated increase in Hb concentration in boys during the 2nd decade. With a change of 1.0 g/dl spread over a 6- to 8-yr period, it is clearly inadvisable to use a single value for "adolescents" when analyzing hematological data from nutrition surveys. The second observation concerns Hb levels in women, which increase in linear fashion from the 20th

TABLE 3
Levels of Hb defined as "deficient" or "abnormal" in this study and in the literature

This study			Literature			
Selected age	Hb cutoff		Age range	Hb cutoff		Reference
	Male	Female		Male	Female	
1	9.8	9.7	B–1	8.5		Sinclair (3)
2	10.7	10.6	<2	<9.0		Ten State Survey (4)
4	11.3	11.0	2–6	9.4		Sinclair (3)
9	11.9	11.9	6–12	<10.0		Ten State Survey (4)
10	11.9	12.0	7–14	10.3		Sinclair (3), Shock (12)
			10–13	11.5		Natvig et al. (2)
14	12.9	12.2	13–16	<12.0	<10.0	Ten State Survey (4)
15	13.2	12.1	15	12.1	10.7	Sinclair (3)
20	14.0	12.1	>16	<12.0	<10.0	Ten State Survey (4)
50	13.7	12.0	"Adult"	<12.0		Manual Nutrition Survey (1)
				14.0	12.0	Wintrobe (5)

through the 60th yr. The 4 decade increase of 0.4 g/dl is also consistent with our unpublished findings from the Ten-State Survey (9, 10). The third observation bears on Hb levels in males, which tend to decrease from the 3rd decade onward, and then (precipitously) in the latter decades of life. Again this male age change in Hb, consistent with our earlier observations, and especially the decrease in the later years bears consideration in population surveys and in surveillance programs.

In summation, these new suggested values for "low" and "deficient" Hb concentrations are based upon a numerically large single source of data (NHANES I). They take into account age changes insofar as they are known, especially in childhood and adolescence and in the later decades of life. The cutoff values designated as "low" (p = 15) and "deficient" (p = 5) are statistically defined and may be used in survey, surveillance and supplementation studies. SD can be used in Z-scoring or T-scoring individuals at risk in population samples. The results of supplementation or dietary improvement can then be so expressed as ΔZ or ΔT.

Of course these new smoothed Hb values apply to nonpregnant North American whites at sea level or moderate elevations. We do not regard them as applicable to blacks, who tend to lower Hb levels even after most careful income matching (10, 11). They may, however, be applied to blacks on an interim basis by subtracting 0.73 g/dl uniformly from all sets of values given in Table 1 (11). Though we have not emphasized substantive findings, the results—especially at p = 50—may be of additional interest when older Americans are involved and for adolescent males when due attention is given to the level of sexual maturity attained.

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