Nutritional Deficiency and Anemia in Latin America:
A Collaborative Study


A collaborative study of nutritional anemia in third trimester pregnancy was performed in seven Latin American countries. Laboratory measurements included hemoglobin level, mean corpuscular hemoglobin concentration (MCHC), serum iron and iron-binding capacity, serum folate, vitamin B₁₂ and albumin. Iron deficiency (transferrin saturation below 15%) was found in 48% of pregnant women, as compared with 21% of nonpregnant females and 3% of male controls of comparable age. The prevalence of folate deficiency (serum folate below 3 ng/ml) was 10%, 10% and 9% in these three groups, respectively. Vitamin B₁₂ deficiency (serum level below 80 pg/ml) was found in 15% of pregnant women, but in less than 1% of both control groups. Anemia, as defined by current WHO criteria, was found in 38.5% of pregnant women, 17.3% of nonpregnant women and 3.9% of men. Analysis of the frequency distribution for hemoglobin levels, based on a Gaussian distribution in normal subjects, suggested that a large portion of subjects considered anemic by WHO criteria were normal and that the true incidence of anemia in pregnant and nonpregnant females was 22 and 12% respectively. Correlation analysis indicated that iron deficiency was of major importance as a cause of anemia, while folate lack was contributory only in pregnancy; no relationship could be demonstrated between vitamin B₁₂ deficiency and anemia.
As a result of a 1963 conference on nutritional anemia held in Caracas, Venezuela, under the auspices of WHO and PAHO, a collaborative study was undertaken to define the prevalence of nutritional deficiencies in Latin America and to determine the extent of related anemia. Because latent deficiencies are frequently unmasked during childbearing, women in the third trimester of pregnancy were chosen as the target population. Additional observations were made on nonpregnant women and men. The data to be presented should not be taken to represent the overall prevalence of nutritional deficiency in the countries studied, since the survey was performed in segments of the population considered to be at greatest risk. It is of interest, however, that in the subjects reported here, who were drawn from the lower socioeconomic class, the prevalence of iron deficiency and anemia is remarkably similar to surveys in the middle and upper economic groups of highly developed countries. The purpose of this report is to document the importance of iron as a nutritional deficiency of high prevalence, and to demonstrate the relationship between the deficiency states studied and anemia.

Materials and Methods

Populations from seven Latin American countries were each divided into three major groups: women in third trimester pregnancy, nonpregnant women, and men. The populations studied in each country were those most available to the collaborating investigator. In Corrientes, Argentina, 83 women in third trimester pregnancy and 25 nonpregnant female controls were studied. All subjects were white city dwellers belonging to a low socioeconomic status relative to the population mean of that country. In São Paulo, Brazil the 130 pregnant subjects, 58% European and 42% Mestizo,* were the wives of laborers in the city of São Paulo. A limited number of controls were comprised of medical students and laboratory technicians. In Medellín, Colombia, an urban population of 66 pregnant women and 55 nonpregnant female controls were studied. Their combined ethnic background was 50% Mestizo, 22% European, and 28% African. Over 90% of these individuals had a low socioeconomic status. In Guatemala, both rural and urban populations were sampled, with about equal representation of European and African subjects, all of low socioeconomic level. This study included 93 pregnant women, with 80 nonpregnant female and 86 male controls. In Mexico City, three separate surveys, designated A, B, and C were performed in third trimester pregnancy. Survey A contained 109 pregnant women from a rural population living in a small town 100 mi from Mexico City (Huamantla, the state of Tlaxcala). In this series, there were 110 nonpregnant female controls and an equal number of males. Surveys B and C were performed without controls on two populations living within Mexico City. All subjects

* Mestizo is a variable mixture of European, Indian, and in certain surveys African ethnic backgrounds.
in the three surveys were Mestizo, but they differed in economic status, ranging from very low in series A to intermediate in series B (average monthly income approximately US $70), to somewhat better in series C (average monthly income of US $100) with the ability to pay for Social Security maternity hospital care. In Lima, Peru, there were 55 pregnant women, 96 nonpregnant females, and 45 male controls, all of the low socioeconomic class living within the city of Lima; 10% were Indian and 90% Mestizo. In Caracas, Venezuela, the subjects lived within the city of Caracas and included 102 pregnant women, 100 nonpregnant females, and 44 males; there was a roughly equal distribution among European, African and Mestizo backgrounds. The pregnant women attended a charity hospital and all subjects belonged to a low socioeconomic status.

In order to standardize the procedures carried out in various laboratories, a reference center for Latin America was established at the Venezuelan Institute for Scientific Investigation, Caracas, Venezuela, where most of the investigators and their technicians received training early in the study. Also, many of the procedures for identifying specific nutritional deficiencies were performed in Caracas on samples shipped there in the frozen state. Details of the standardization measures and their effectiveness are described elsewhere.6

The WHO protocol employed in the overall study included 33 different items pertaining to the history, physical examination, and laboratory findings. The analysis presented here involves only those parameters relating to anemia and its cause; included are the concentration of hemoglobin in whole blood, performed by the cyanmethemoglobin method,7 mean corpuscular hemoglobin concentration, serum iron,8,9 iron-binding capacity,9,10 transferrin saturation, and the concentration in serum of albumin, folate,12 and vitamin B12.13,14 Hemoglobinopathies were known to be uncommon in the sampled populations.

The results of the individual and composite surveys were expressed as the median and as the 10th and 90th percentile values. The latter were included because of the skewed distribution in several of the laboratory measurements. The hemoglobin levels were corrected for altitude by subtracting amounts based on the data of Hurtado et al.15 The corrections were as follows:

<table>
<thead>
<tr>
<th>Population Origin</th>
<th>Altitude (M)</th>
<th>Correction (g/100 ml blood)</th>
</tr>
</thead>
<tbody>
<tr>
<td>São Paulo, Brazil</td>
<td>750</td>
<td>0.2</td>
</tr>
<tr>
<td>Medellin, Colombia</td>
<td>1500</td>
<td>0.5</td>
</tr>
<tr>
<td>Guatemala City, Guatemala</td>
<td>1850</td>
<td>0.8</td>
</tr>
<tr>
<td>Mexico City, Mexico</td>
<td>2250</td>
<td>1.1</td>
</tr>
<tr>
<td>Caracas, Venezuela</td>
<td>2550</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>900</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The criteria used for defining nutritional deficiency were those established by WHO Study Group on Nutritional Anemias in 1968.16 A state of iron deficiency was considered to exist with a transferrin saturation below 15%, deficiency of folate at a serum level below 3 ng/ml., vitamin B12 below 80 pg/ml.

Anemia was defined both on an individual and a population basis. For the former, WHO criteria16 were employed in which anemia was based on a hemoglobin level less than 11 g/100 ml in the pregnant woman, less than 12 g/100 ml in the nonpregnant woman, and less than 13 g/100 ml in men. The prevalence of anemia in the population was derived by analysis of the frequency distribution of hemoglobin levels. The assumption was made that the distribution of hemoglobin values in the tested population was actually composed of two separate Gaussian distributions, one of normal and the other of anemic individuals. The premise of two populations was supported by the marked deviation from a single Gaussian distribution observed in the lower portion of the accumulated frequency distribution curve of hemoglobin values in pregnant and nonpregnant females. A solution was obtained by searching several thousand theoretical curves with a digital computer to determine the value which gave the lowest sum of squared differences between the fitted and observed frequency distribution of hemoglobin values.

Correlation analysis was used to determine the relationship among the various laboratory
measurements. Correlation coefficients for each pair of laboratory measurements were calculated separately for the three subject groups in each country, thus permitting an examination of findings in individual surveys. It was found appropriate to pool the correlation coefficients for the individual surveys into two major groups of pregnant and male and female control subjects; the homogeneity of correlation coefficients within each of these two groups was established by chi square tests of the z-transforms. The pooled correlation coefficients were calculated from the weighted z-transforms of the individual coefficients.

RESULTS

The following analysis is a composite description of the entire group of subjects studied. The ethnic background was 23% European, 15% African, 2% Indian, and 60% Mestizo. All but 5% of subjects belonged to the low socioeconomic population segment. Fewer than 0.5% of the subjects were below age 15; about a third were between 15 and 20; about two thirds were between 20 and 40. Only 2.7% of the pregnant women and 12.7% of the controls were over 40. In 27% of the pregnant subjects, parity was one or less; in 39% it was between two and four; in 36% it was greater than four. In the nonpregnant women, percentages were 14.2, 36.1, and 49.6, respectively. The gestation time at which sampling occurred was 28 wk or greater in all series; the median time for the combined data was 35 wk, ranging from 32–40 wk in the individual series.

The laboratory data obtained in the individual populations are summarized in Table 1. Appreciable differences are apparent. For example, the median
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<table>
<thead>
<tr>
<th>Parameters of Nutritional Anemia</th>
<th>TIBC  †</th>
<th>Transferrin Saturation</th>
<th>Serum Folate</th>
<th>Serum Vitamin B12</th>
<th>Serum Albumin</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Cases</td>
<td>Median (µg/100 ml)</td>
<td>10-90 Percentile (µg/100 ml)</td>
<td>No. of Cases</td>
<td>Median (%)</td>
<td>10-90 Percentile (%)</td>
</tr>
<tr>
<td>76</td>
<td>508</td>
<td>384-630</td>
<td>76</td>
<td>14.8</td>
<td>6.0-25.7</td>
</tr>
<tr>
<td>87</td>
<td>505</td>
<td>392-594</td>
<td>87</td>
<td>10.6</td>
<td>3.8-19.2</td>
</tr>
</tbody>
</table>

* Mean corpuscular hemoglobin concentration.

† Total iron-binding capacity.

Mean weighted according to the number of observations in each group.

The hemoglobin value in pregnant subjects varied from 10.2 to 12.2 g/100 ml. Even greater differences than these were observed among the lower 10 percentiles. However, there was substantially better agreement in the upper 10 percentiles, suggesting that the data are correct and that the median differences reflect variability in the proportion of abnormal subjects. This assumption is supported by the lack of variability among hemoglobin values of male subjects, in whom anemia is uncommon.

The accumulated frequency distribution curve for parameters of the various nutrients are shown in Fig. 1. While clear differences in serum iron and transferrin saturation were observed between men and women (Fig. 1A, B) only the transferrin saturation clearly separated pregnant and nonpregnant women. As defined by the WHO criteria of a transferrin saturation below 15%, iron deficiency had an incidence of 48.5%, 21.2%, and 3.0% in pregnant women, nonpregnant women, and men, respectively. Folate levels differed only minimally among the three groups, the incidence of deficiency levels being 10.1%, 9.8%, and 9.0% (Fig. 1C). On the other hand, serum B12 levels varied greatly, with 15.4% of the pregnant women having deficient vitamin B12 levels as compared with less than 1% in the two other groups (Fig. 1D).

The accumulated frequency distributions of hemoglobin levels for the entire
study are shown in Fig. 2. Based on WHO criteria, the prevalence of anemia among the three groups of tested subjects was 38.5% of pregnant women, 17.3% of nonpregnant women, and 3.9% of men. When the distributions given in Fig. 2 for pregnant and nonpregnant women were plotted on probability paper (Fig. 3), only the upper portion followed a linear pattern typical of a single Gaussian distribution. This deviation was minimal in the male population where the hemoglobin distribution could be closely fitted by a single Gaussian curve (mean hemoglobin level 15.0 ± 1.1) that contained no more than 2% of a second population with lower hemoglobin values. In both female groups, a double population of hemoglobin values was evident. Table 2 compares the observed and fitted cumulative frequency distributions in third trimester of pregnancy, where 78% of the subjects comprised a population with higher hemoglobin values (mean 11.8 ± 1.2 g/100 ml) and 22% in a population with lower levels (mean 9.8 ± 1.8 g/100 ml). Among nonpregnant women, 88% were contained in the upper population (mean hemoglobin 13.1 ± 1.0), while the remaining 12% fell in the lower distribution (mean 10.6 ± 1.9).

Correlations among the various laboratory tests are shown in Table 3. The
measurements evaluating iron status (serum iron-binding capacity, and transferrin saturation) were highly correlated with red cell measurements (hemoglobin level and MCHC) in both the pregnant and control groups. A high correlation was also observed between hemoglobin and serum albumin levels. The correlation between serum folate and hemoglobin was much lower in pregnancy and absent in controls. No relation was observed between serum B12 level and red cell parameters.

DISCUSSION

Traditionally, population studies of nutritional deficiencies which affect the blood have started by identifying the anemic population and then ascertaining its cause. The implication has been that only those individuals with hemoglobin below an arbitrary level have a pathologic depression in hemoglobin, and that all individuals above that hemoglobin level do not have a deficiency state. Since neither of these assumptions is valid, since the prevalence of deficiency may be assumed to be considerably greater than the prevalence of related anemia, and since sensitive methods exist for detection of deficiency states, emphasis clearly should be placed on the initial recognition of the
Table 2.—Comparison of Distributions of Hemoglobin Values in Pregnancy

<table>
<thead>
<tr>
<th>Hemoglobin g/100 ml</th>
<th>Cumulative Frequency Distributions Fitted*</th>
<th>Observed Combined %</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fitted* Lower Upper Combined (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 8.5</td>
<td>3.3 0.1 3.4</td>
<td>4.1 -0.7</td>
<td></td>
</tr>
<tr>
<td>≤ 8.0</td>
<td>5.0 0.3 5.3</td>
<td>5.5 -0.2</td>
<td></td>
</tr>
<tr>
<td>≤ 9.0</td>
<td>7.3 0.9 8.1</td>
<td>7.6 0.5</td>
<td></td>
</tr>
<tr>
<td>≤ 9.5</td>
<td>9.7 2.4 12.1</td>
<td>12.1 0.0</td>
<td></td>
</tr>
<tr>
<td>≥ 10.0</td>
<td>12.3 5.6 17.9</td>
<td>17.1 0.8</td>
<td></td>
</tr>
<tr>
<td>≥ 10.5</td>
<td>14.8 11.6 26.4</td>
<td>26.6 -0.2</td>
<td></td>
</tr>
<tr>
<td>≥ 11.0</td>
<td>17.0 20.7 37.7</td>
<td>38.1 -0.4</td>
<td></td>
</tr>
<tr>
<td>≥ 11.5</td>
<td>18.6 32.6 51.2</td>
<td>51.2 0.0</td>
<td></td>
</tr>
<tr>
<td>≥ 12.0</td>
<td>20.0 45.4 65.4</td>
<td>64.5 0.9</td>
<td></td>
</tr>
<tr>
<td>≥ 12.5</td>
<td>20.8 57.3 78.1</td>
<td>78.6 -0.5</td>
<td></td>
</tr>
<tr>
<td>≥ 13.0</td>
<td>21.4 66.4 87.8</td>
<td>88.1 -0.3</td>
<td></td>
</tr>
<tr>
<td>≥ 13.5</td>
<td>21.7 72.4 94.1</td>
<td>94.3 -0.2</td>
<td></td>
</tr>
<tr>
<td>≥ 14.0</td>
<td>21.9 75.6 97.5</td>
<td>97.8 -0.3</td>
<td></td>
</tr>
</tbody>
</table>

*The population with lower hemoglobin levels, which presumably represents subjects with anemia, comprised 22% of the total series.

deficiency and then its severity evaluated as reflected in anemia.

Iron lack was the commonest abnormality observed in the present survey. In iron deficiency, there is both a decrease in serum iron and an increase in transferrin concentration. Since the degree of transferrin saturation is affected

Table 3.—Correlation Coefficients of Laboratory Test Results*

<table>
<thead>
<tr>
<th>Third trimester pregnancy</th>
<th>Hemoglobin</th>
<th>MCHC</th>
<th>Lobe Count</th>
<th>Serum Albumin</th>
<th>Serum Folate</th>
<th>Serum Vitamin B12</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCHC</td>
<td>.56 §</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lobe count</td>
<td>-.11 -1.1</td>
<td>-1.7</td>
<td>-.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum albumin</td>
<td>.22 §</td>
<td>.12</td>
<td>-.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum folate</td>
<td>.12 §</td>
<td>.04</td>
<td>-.20 §</td>
<td>.13 §</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum vitamin B&lt;sub&gt;12&lt;/sub&gt;</td>
<td>.06 .08</td>
<td>-.04</td>
<td>-.15 §</td>
<td>.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIBC</td>
<td>-.19 §</td>
<td>-.14</td>
<td>.11 †</td>
<td>.14 §</td>
<td>-.04 -1.0</td>
<td></td>
</tr>
<tr>
<td>Serum iron</td>
<td>.37 §</td>
<td>.21</td>
<td>.05</td>
<td>.12 §</td>
<td>.07 †</td>
<td>-.02</td>
</tr>
</tbody>
</table>

*The correlations are based on approximately 1000 observations in pregnancy and 700 in the combined control groups except for lobe count and serum albumin which were based on 200–300 observations in both series.

† p < .05.

‡ p < .01.

§ p < .001.

|| Correlations with the serum iron and transferrin saturation were nearly identical.
by both of these changes, it is a sensitive indicator of iron supply to the tissues. In pregnancy, however, there is a rise in transferrin concentration unrelated to iron deficiency, and the question could be posed whether transferrin saturation still constitutes the best index of adequacy of iron supply. The data presented in this study show that during pregnancy, the level of transferrin saturation is a better indicator of iron deficiency than the level of serum iron. Thus, if one takes as the definition of iron deficiency, a serum iron below 50 μg/100 ml, its incidence in the pregnant and nonpregnant women tested is similar (15.6% and 13.6%, respectively). However, when iron deficiency is defined as a transferrin saturation below 15%, there is a highly significant difference between the two groups (48% vs. 21%). Since the state of iron deficiency should be more prevalent than its manifestations as anemia, and since anemia as defined by either WHO criteria or by population analysis is shown here and in previous studies to be more frequent in women who are pregnant, the superiority of the transferrin saturation measurement seems well supported.

Folate deficiency was found in 10.1%, 9.8%, and 9.0% of the three groups of subjects tested. However, the relevance of these figures in the control groups is questionable since their folate levels and red cell measurements were not significantly correlated with subnormal hemoglobin values. In pregnancy only, a significant correlation was observed between the serum folate and the hemoglobin level, although the strength of this association was small compared with iron.

Significant vitamin B12 deficiency was seen only in pregnancy (prevalence 15.4%). However, the biological significance of serum B12 measurements in late pregnancy is open to question. Microbiological assays of the vitamin have yielded several reports of low levels occurring in both anemic and non-anemic pregnant women, despite supplemental vitamin B12 administration. On the other hand, normal levels have usually been reported with the radioactive charcoal method, which suggests that during pregnancy, an inhibitor may be present in the serum which interferes with the microbiological technique. This is supported by the present study where the radioactive method was employed only in the Mexico series and where the incidence of vitamin B12 deficiency was significantly lower.

The correlations observed between the serum albumin and several of the remaining laboratory tests (MCHC, transferrin saturation, and serum folate) are rather difficult to explain. The association may be an indirect one in which the nutritional status of the patient is reflected both in the level of serum albumin and in the occurrence of deficiencies of iron and folate. The relationship between iron status and the serum albumin might also be explained by the role of animal protein in facilitating dietary iron absorption. While it is true that protein deprivation may be associated with a reduction in blood hemoglobin levels, the degree of protein depletion required is very severe; the extreme degree of hypoalbuminemia required for such an effect was not observed among the subjects tested.

The problem of identifying anemia in the patient with nutritional deficiency can be approached in three ways. The usual approach is to separate normal
and anemic subjects on the basis of some arbitrary hemoglobin level, in which case the incomplete separation of the two populations will inevitably involve errors in the diagnosis of both normal and anemic individuals. Thus, the use of a single hemoglobin definition not only involves an incorrect diagnosis of anemia in a certain proportion of normal subjects, but it also fails to detect the patient whose hemoglobin level customarily lies in the upper range of normal and who may have a decrease in hemoglobin of more than 2 g/100 ml due to his deficiency, without falling below the arbitrary cutoff point. A more meaningful approach would be to define as anemic, those subjects who show a significant improvement in the hemoglobin with correction of nutritional deficiency. This definition has been used by Garby et al. in a Swedish population of menstruating women given either placebo or iron therapy for 3 mo. It was found that when the initial hematocrit, which best separated the anemic from nonanemic subjects (38%) was used to define anemia, about 17% of truly anemic women were wrongly classified as normal, while about 21% of normal women were misclassified as anemic.

In the present study, a third method was employed that defines anemia on a population basis rather than in the individual subject. The method takes advantage of the fact that hemoglobin levels in normal subjects follow a Gaussian distribution. The latter was established in the present study in male subjects, where the hemoglobin level showed a near perfect fit to a Gaussian curve, and in the two remaining female populations, where the upper half of the frequency distribution was strictly linear when plotted on probability paper. By extracting a second population with lower mean hemoglobin levels, the prevalence of anemia was found to be 22% in pregnant females, 12% in nonpregnant women and negligible (2%) in the male population. Thus in pregnancy, of every 100 women sampled, 22 were anemic, of which 17 fell below, and 5 above the level of 11 g hemoglobin used as the WHO criteria of anemia (Fig. 4). Of the 78 women in the normal distribution curve, only 57 were regarded as normal by WHO criteria, while 21 were incorrectly classified as anemic. For every 100 nonpregnant females sampled, 12 were anemic, of which two had been considered normal by WHO criteria, while of the 88 subjects falling within the normal distribution, nine had been incorrectly considered anemic by these criteria. Thus, true anemia cannot be defined by a hemoglobin concentration but must be identified by a response to treatment or as belonging to the lower of two populations extracted from the frequency distribution curve of hemoglobin values.

The proposed relationship between iron deficiency and true anemia is indicated in Table 4. Although the population definition of anemia used in this report has failed to indicate, in the individual subject, whether anemia invariably results from iron deficiency, some support for this is provided by the high correlations observed between iron and red cell parameters shown in Table 3, and by the close relationship in the three populations between the prevalence of anemia and iron deficiency. The assumption may be further tested by examining the frequency of iron deficiency in normal subjects which fall above and below the hemoglobin level used as the WHO criteria of anemia. If an exact relationship does not exist between anemia and iron deficiency,
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Fig. 4.—Fitted double population of hemoglobin levels in third trimester pregnancy. The vertical line depicts the hemoglobin value used to define anemia according to WHO criteria. The larger area represents the distribution of normal population and the smaller area, the anemic group. The stippled area above 11 g/100 ml represents subjects found anemic by distribution analysis but considered normal by WHO criteria. The cross-hatched area below 11 g/100 ml represents that portion of the population found normal by distribution analysis but considered anemic by WHO criteria.

the prevalence of iron deficiency in the normal subjects above and below the hemoglobin level used by WHO to define anemia would differ after removal of those associated with anemia. For every 100 pregnant women sampled, 48 were iron deficient of which 24 were classified as anemic by WHO criteria. If we remove the 17 women who had true anemia, the prevalence of deficiency in the 21 women who were incorrectly classified as anemic is 7/21 or 33%. In the 24 women with iron deficiency and a hemoglobin level above 11 g/100 ml, five could be explained by true anemia leaving a prevalence of iron deficiency in the 57 normal subjects of 19/57 or again 33%. The prevalence of iron deficiency in pregnant women without anemia above and below the WHO criteria of 11 g/100 ml hemoglobin was thus similar, despite removal of different portions of iron-deficient subjects who had true anemia.

Causes of anemia observed in the present report other than iron deficiency are extremely unlikely. Although chronic infection might explain the direct correlation between serum iron and hemoglobin values, a decreasing hemoglobin level was associated with an increase rather than a decrease in the TIBC as would be seen in infection. In addition, white blood cell counts

<table>
<thead>
<tr>
<th></th>
<th>Iron Deficiency</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>With Anemia</td>
<td>Without Anemia</td>
</tr>
<tr>
<td>Pregnant females</td>
<td>48</td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td>Nonpregnant females</td>
<td>21</td>
<td>12</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 4.—Prevalence of Iron Deficiency With and Without Anemia
were obtained in the majority of the surveys and showed no correlation with anemia. Hemoglobinopathies were likewise excluded by reticulocyte counts performed in the majority of subjects and, again, failed to correlate with the anemia observed. Most important, the virtual absence of anemia in the male population would exclude infection or hemoglobinopathies as a possible cause of anemia observed.

There seems little reason to consider either the populations studied or the results obtained in the present survey to be unique. Iron deficiency and iron-deficiency anemia are widespread, not only in low but in high socioeconomic classes as well. It is possible that the prevalence of iron-deficiency anemia could be increased or decreased somewhat by population selection, but this would affect little the conclusion reached: virtually all true anemia in the healthy population is due to iron deficiency.

In the present survey, hookworm was undoubtedly an important contributory cause of the iron-deficiency anemia in several of the populations, particularly in Corrientes, Argentina. The possibility of malabsorption of dietary iron, although not clinically evident, cannot be excluded. Importance of the diet as a cause of the iron-deficiency anemia is difficult to assess, and dietary surveys in Latin America have not been helpful in explaining the iron deficiency observed in population surveys. The correlation between iron deficiency and low serum albumin does suggest however, that attention should be directed at the relationship between protein intake and iron balance.

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REFERENCES

11. Herbert, V., Gottlieb, C. W., Lau, K-S, Fisher, M., Gevirtz, N. R., and Wasser-
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