

MEDICAL EVALUATION OF NUTRITIONAL STATUS¹

V. PREVALENCE OF DEFICIENCY DISEASES IN THEIR SUBCLINICAL STAGE

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WITH the development of methods for diagnosing nutritional deficiencies while the condition is in a very early or mild stage, it becomes possible to determine the prevalence of such deficiency diseases in various groups of the population. The frank or fully developed deficiency diseases, such as pellagra, scurvy, and beriberi, which can be diagnosed by usual clinical methods, occur to some extent in the United States, but data from extensive and careful analyses of American diets have provided important, though inferential, evidence that a very large number of persons are malnourished with respect to one or more essential food elements. Research in recent years has disclosed the bodily changes which result from insufficient amounts of some of the specific nutrients when deprivation has not been severe enough to produce frank deficiency diseases. For a few of the subclinical changes caused by specific deficiencies, diagnostic procedures are now available which can be used for surveys of large groups of persons to determine the prevalence of mild cases of deficiency diseases.

From an investigation in New York City on Medical Evaluation of Nutritional Status, which is a cooperative study conducted by the Cornell University Medical College, the Milbank Memorial Fund, the New York City Department of Health, and the United States Public Health Service, with assistance from the WPA, some data on prevalence of four nutritional deficiencies are presented in this report. In this Study, which has been described (1), emphasis has

¹ This paper is the fifth of a series from a cooperative investigation by the Cornell University Medical College, Department of Public Health and Preventive Medicine and Department of Pediatrics; the Milbank Memorial Fund; the New York City Department of Health; and the United States Public Health Service, Division of Public Health Methods.

The cooperating agencies have been assisted in carrying out this investigation by the Work Projects Administration for the City of New York, Official Project No. 65-1-97-21, W. P. 24, "Medical Evaluation of Nutritional Status."

been placed on the appraisal of procedures, and in the two years during which examinations have been made, new tests have been added to the procedures as they became available. For the present report results of examinations for avitaminosis A, ariboflavinosis, anemia, and low ascorbic acid levels in blood plasma are tabulated for those persons in the Study who received all or nearly all of the tests for these deficiencies.

DIAGNOSTIC PROCEDURES

Avitaminosis A reported here is based on changes in the conjunctiva detected by an examination with a biomicroscope under slit-lamp illumination. The examination and criteria for pathological changes have been fully described in another report (2) from this Study. Cases are classified in three stages according to the degree of light transmission: (1) those with minimum change, showing definite translucency; (2) those with somewhat more advanced change, characterized by opacity; and (3) cases in which opaque areas are thickened to the point of elevation, termed spot cases. Conjunctival alteration may be present in either the nasal or temporal zone, or both, of either or both eyes, and the case is classified according to the most advanced stage noted in one or more zones.

Ariboflavinosis cases are diagnosed on the basis of keratitis disclosed by a biomicroscopic examination with slit-lamp illumination (3, 4). Persons showing only vascular arcades around the limbus have not been counted as deficient, but those with capillaries noted as having extended into the cornea in one or both eyes have been counted as cases of ariboflavinosis. The cases are subdivided into three groups as follows: (1) those with short "twigs" in cornea of either eye or each eye; (2) those with 1 to 4 capillary "streamers" in cornea of either eye or each eye; and (3) those with 5 or more "streamers" in either eye or each eye.

The determination of the amount of hemoglobin in the blood to select persons with anemia was based upon the colorimetric deter-

mination of oxyhemoglobin by the Evelyn method, using the photoelectric colorimeter (5).

Ascorbic acid level of fasting plasma was determined on a macro sample by the photoelectric colorimeter method (6), based upon the reduction of 2:6 dichlorophenol-indophenol. The evidence on vitamin C nutrition derived from plasma ascorbic acid differs in its significance from the evidence on vitamin A, riboflavin, and iron. For the latter three, the examination reveals changes which have been produced over a period of time by subnormal nutrition, whereas plasma vitamin C may vary within a short time, or from day to day, and does not necessarily reflect the nutritive state of the body with respect to vitamin C.

PERSONS EXAMINED

Examinations on high school students from families of low income and of relatively high income furnished the major part of the data in this report.

The low-income group is from Seward Park High School, in the lower East Side district of Manhattan. Examinations were made in the winter of 1940-1941 on about 500 pupils, most of whom were examined for all four deficiencies mentioned above. The economic status of the families of these pupils is revealed in Table 1, which

Table 1. Weekly income reported by families with children who were examined in Seward Park High School in the winter of 1940-1941.

INCOME STATUS	PER CENT OF TOTAL	NUMBER OF FAMILIES WITH INCOME KNOWN
ALL FAMILIES	100.0	473
Relief		
WPA	8.9	42
All Other	12.3	58
Non-Relief		
Less Than \$20.00	10.1	48
\$20.00—\$34.99	40.2	190
\$35.00 and Over	28.5	135

gives the weekly income reported to a home visitor, who usually interviewed the child's mother. Twenty-one per cent of the families were receiving assistance; either a member of the family had work relief, or the family was receiving some type of aid from a private or public relief agency. Nearly 30 per cent of the families had an income from earnings of \$35 or more per week, leaving about 50 per cent with less than \$35 per week and not on relief. The families are predominantly Jewish, and parents of the examined students were largely foreign born. Most of the non-Jewish children were of Italian parentage, one or both parents being foreign born.

The high-income group includes about 350 pupils in a private school in New York City, the Fieldston School of the Ethical Culture Schools. Children in this group were examined in the early spring of 1940 and did not have an examination of the conjunctiva for avitaminosis A. For nearly all pupils in this group, data are available on hemoglobin values, plasma ascorbic acid, and keratitis.

During the period from July, 1939 to May, 1941, hemoglobin values and plasma ascorbic acid levels have been determined for 136 persons employed by the WPA, and for a few more, one of the determinations was made. In addition, 138 such employes received an eye examination to detect the presence of keratitis, and 143 received an examination to discover conjunctival changes characteristic of avitaminosis A. In relatively few instances did the same person receive all four of these tests.

PREVALENCE OF THREE DEFICIENCIES IN A HIGH-INCOME GROUP

Among the pupils in the high-income group, few persons showed evidence of a dietary deficiency of ascorbic acid, iron, or riboflavin. Prevalence rates for deficiencies in each of these nutrients are given in Table 2. None of the boys was found to have hemoglobin values significantly low² and none showed vascularization of the cornea

²No accepted and generally approved standards for satisfactory hemoglobin values for boys and girls between 12 and 20 years of age are available. Tentative standards used here

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CLASSIFICATION OF FINDINGS	PERCENTAGE OF TOTAL			NUMBER EXAMINED		
	Both Sexes	Boys	Girls	Both Sexes	Boys	Girls
ASCORBIC ACID IN PLASMA						
TOTAL	100.0	100.0	100.0	342	178	164
0.00-0.39 mg. %	2.9	3.9	1.8	10	7	3
0.40-0.59 mg. %	2.6	2.8	2.4	9	5	4
0.60-0.99 mg. %	21.3	24.7	17.7	73	44	29
1.00 or More mg. %	73.1	68.5	78.0	250	122	128
HEMOGLOBIN CLASSIFICATION						
TOTAL	100.0	100.0	100.0	336	175	161
Below "Standard" ¹ Standard or Higher	1.5 98.5	0 100.0	3.1 96.9	5 331	0 175	5 156
KERATITIS—ARIBOFLAVINOSIS						
TOTAL	100.0	100.0	100.0	354	183	171
Vessels in Cornea	2.3	0	4.7	8	0	8
No Corneal Invasion	97.7	100.0	95.3	346	183	163

¹ For standards for hemoglobin used, see footnote 2.

Table 2. Prevalence of three nutritional deficiencies among high school students from high-income families in New York City.

under slit-lamp examination. Plasma ascorbic acid levels less than 0.6 mg. per cent were found for 6.7 per cent of boys. Among girls, some cases of each deficiency were diagnosed. Hemoglobin values less than 12.0 grams per 100 cc. of blood were found for 5 girls, or 3.1 per cent; all had mild anemia with hemoglobin values between 10.0 and 12.0 grams. Examination of the cornea showed eight girls, or 4.7 per cent, had vascularization characteristic of a mild riboflavin deficiency; and plasma ascorbic acid levels were less than 0.6 mg. per cent for 4.2 per cent of the group.

were derived from a special analysis of this high-income group and take account of both chronological and physiological age. The values used for a minimum level were: for boys, under 13 years of age, 12.0 gms. per 100 cc.; 13 years and older, with no pubic hair, 12.0 gms.; with sparse pubic hair, 12.8 gms.; with moderate or abundant pubic hair, 13.5 gms.; for all girls, 12.0 gms. Changes in hemoglobin levels by age during adolescence have been described (7) and, in a later report, a detailed analysis of the relation of physiological development to changes in hemoglobin levels will be presented.

All of the girls showing one of these deficiencies had all three tests, and in no case was there a multiple deficiency. Thus, among 161 girls with all three tests, there were twenty, or 12.4 per cent, with one deficiency. Results of all three tests are available for 336 boys and girls, and 9.5 per cent showed evidence of a nutritional deficiency in either iron, ascorbic acid, or riboflavin.

PREVALENCE OF FOUR DEFICIENCIES IN A LOW-INCOME GROUP

The prevalence of four nutritional deficiencies among the pupils from low-income families is shown in Table 3, and the rates are strikingly different from those for the high-income group with the exception of that for low hemoglobin values. The percentage of children showing some stage of avitaminosis A was 86.6; the percentage with mild ariboflavinosis was 75.8; the percentage with plasma ascorbic acid less than 0.60 mg. per cent was 49.9; and the percentage with hemoglobin values below the assigned minimum was 3.3. Boys more frequently than girls were found to show relatively advanced stages of these deficiencies except iron. Thus, among boys examined for avitaminosis A, 9.4 per cent was in the "spot case" class and among girls, there was 5.6 per cent; keratitis with 5 or more capillary "streamers" in the cornea was found in 10.8 per cent of boys and 4.2 per cent of girls; and the comparative percentages for boys and girls with plasma ascorbic acid below 0.60 mg. per cent were 55.6 and 42.3, respectively. Anemia, on the other hand, was more prevalent among girls; but, for both sexes, the few cases considered subnormal were only slightly below the minimum hemoglobin levels.

When comparisons are made between rates for the total prevalence of each deficiency disease, the proportions in each according to severity should be borne in mind. The cases of avitaminosis A and ariboflavinosis each have been arbitrarily classified into three stages; but the gradations of severity of one deficiency are not equivalent to those of the other. For example, stage 3 of avitaminosis A repre-

CLASSIFICATION OF FINDINGS	PERCENTAGE OF TOTAL			NUMBER EXAMINED		
	Both Sexes	Boys	Girls	Both Sexes	Boys	Girls
CONJUNCTIVAL CHANGE—AVITAMINOSIS A						
TOTAL	100.0	100.0	100.0	494	278	216
Spot Case	7.7	9.4	5.6	38	26	12
Opacity	41.3	40.6	42.1	204	113	91
Marked Translucency						
3-4 Zones	33.4	34.5	31.9	165	96	69
1-2 Zones	4.3	3.6	5.1	21	10	11
No Marked Translucency	13.4	11.9	15.3	66	33	33
KERATITIS—ARIBOFLAVINOSIS						
TOTAL	100.0	100.0	100.0	495	279	216
5 or More Streamers	7.9	10.8	4.2	39	30	9
1-4 Streamers	34.7	32.3	38.0	172	90	82
Twigs Only	33.1	32.6	33.8	164	91	73
No Corneal Invasion	24.2	24.4	24.1	120	68	52
ASCORBIC ACID IN PLASMA						
TOTAL	100.0	100.0	100.0	425	241	184
0.00-0.39 mg. %	32.0	34.0	29.3	136	82	54
0.40-0.59 mg. %	17.9	21.6	13.0	76	52	24
0.60-0.99 mg. %	25.2	24.1	26.6	107	58	49
1.00 or More mg. %	24.9	20.3	31.0	106	49	57
HEMOGLOBIN CLASSIFICATION						
TOTAL	100.0	100.0	100.0	425	241	184
Below "Standard" ¹	3.3	2.5	4.3	14	6	8
Standard or Higher	96.7	97.5	95.7	411	235	176

¹ For standards for hemoglobin, see footnote 2.

Table 3. Prevalence of four nutritional deficiencies among high school students from low-income families.

sents a more advanced stage of xerosis than stage 3 of arboflavinosis does of keratitis.

With such high proportions of these high school students deficient in vitamin A, riboflavin, and ascorbic acid, it is obvious that many had multiple deficiencies. In fact, if only vitamin A and ribo-

DEFICIENCIES ¹	Boys		GIRLS	
	No.	Per Cent	No.	Per Cent
TOTAL	241	100.0	184	100.0
4: A+R+C+ Iron	1	0.4	4	2.2
3: A+R+C	83	34.4	42	22.8
A+R+ Iron	2	0.8	0	0
A+C+ Iron	2	0.8	0	0
R+C+ Iron	0	0	1	0.5
2: A+R	77	32.0	66	35.9
A+C	27	11.2	16	8.7
A+ Iron	0	0	1	0.5
R+C	13	5.4	11	6.0
R+ Iron	0	0	1	0.5
C+ Iron	1	0.4	1	0.5
1: A	17	7.1	24	13.0
R	7	2.9	14	7.6
C	7	2.9	3	1.6
None	4	1.7	0	0

¹A is vitamin A, R is riboflavin, C is vitamin C (ascorbic acid.)

Table 4. Percentage of students in low-income group who had specified combinations of deficiency diseases.

flavin are considered, two-thirds (66.2 per cent) of the 494 children receiving both examinations showed evidence of both deficiencies; and only eighteen, or 3.6 per cent, had neither deficiency. When all four deficiencies are considered for the 425 children with both eye examinations and blood analyses, only four (all boys) were free of any deficiency. The frequency of various combinations of deficiencies is shown in Table 4. Since there were few persons with low hemoglobin, there could be very few who had all four deficiencies, but it is interesting that four of the eight girls who were deficient in iron were also deficient in the three vitamins. The percentage for three deficiency cases was 36.0 among boys and this was 50 per cent higher than the prevalence of three deficiency cases among girls. Conversely, 22 per cent of the girls and 13 per cent of the boys had a single deficiency.

PREVALENCE OF SPECIFIC DEFICIENCIES AMONG WPA EMPLOYEES

The percentages of employes of the WPA who showed specific deficiencies are given in Table 5. This group had an age range of 17 to 65 years, but the great majority were between 25 and 50 years of age.

Conjunctival change indicative of avitaminosis A was observed

Table 5. Prevalence of four nutritional deficiencies among adults employed by WPA.

CLASSIFICATION OF FINDINGS	PERCENTAGE OF TOTAL			NUMBER EXAMINED		
	Both Sexes	Males	Females	Both Sexes	Males	Females
XEROSIS CONJUNCTIVAE—AVITAMINOSIS A						
TOTAL	100.0	100.0	100.0	143	99	44
Spot Case	45.5	52.5	29.5	65	52	13
Opacity	31.5	30.3	34.1	45	30	15
Marked Translucency						
3-4 Zones	14.0	10.1	22.7	20	10	10
1-2 Zones	8.4	7.1	11.4	12	7	5
No Marked Translucency	0.7	0	2.3	1	0	1
KERATITIS—ARIBOFLAVINOSIS						
TOTAL	100.0	100.0	100.0	138	92	46
Vessels in Cornea	38.4	37.0	41.3	53	34	19
No Corneal Invasion	61.6	63.0	58.7	85	58	27
ASCORBIC ACID IN PLASMA						
TOTAL	100.0	100.0	100.0	165	104	61
0.00-0.39 mg. %	39.4	49.0	23.0	65	51	14
0.40-0.59 mg. %	15.8	16.3	14.8	26	17	9
0.60-0.99 mg. %	24.2	24.0	24.6	40	25	15
1.00 or More mg. %	20.6	10.6	37.7	34	11	23
HEMOGLOBIN LEVEL						
TOTAL	100.0	100.0	100.0	138	79	59
10.0-11.9 gms.	3.6	1.3	6.8	5	1	4
12.0-13.9 gms.	30.4	6.3	62.7	42	5	37
14.0 or More	65.9	92.4	30.5	91	73	18

in 142 of 143 persons examined with a slit lamp. The more advanced changes, classified as "spots," were observed in sixty-five, or 45.5 per cent, of the group. This may be compared with 7.7 per cent of "spot cases" among the high school pupils in the low-income group, and it is evident that the adult group was much more seriously deficient in vitamin A. The prevalence of "spot" cases among the men was nearly eighty per cent higher than among the women.

Slit-lamp examination for keratitis of 138 persons showed that 38.4 per cent had a riboflavin deficiency. There was no significant difference in the prevalence for men and women. The records for this group did not permit classification of the stage of keratitis comparable to that used for the high school group; but the total prevalence of 38.4 per cent is only slightly more than one-half that found in the low-income group of high school pupils.

Plasma ascorbic acid levels were less than 0.60 mg. per cent for ninety-one of 165 adults, or 55.2 per cent. As in the high school groups, low ascorbic acid values were more prevalent among men than among women, 65.3 per cent as against 37.8 per cent.

A hemoglobin level below standard was the least frequent deficiency observed among this adult group, but it was somewhat more prevalent than among either of the two high school groups. Among the women, 6.8 per cent had less than 12.0 grams of hemoglobin per 100 cc. of blood, and 7.6 per cent of men had values below 14.0 grams.

Multiple deficiencies must have been common among these adults. Since the prevalence of avitaminosis A was nearly 100 per cent, the majority must have been deficient also in riboflavin or vitamin C.

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