NUTRITIONAL STATUS OF INDUSTRIAL WORKERS[1, 2]

I. DIETARY, BLOOD, AND PHYSICAL FINDINGS

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INTRODUCTION

FEW comprehensive studies have been made of the nutritional status of industrial workers, although it is generally recognized that adequate nutrition of workers is necessary for high production levels (National Research Council, 1945; *Nutrition Reviews,* 1953). Prior to the enrichment program, Borsook and co-workers studied the nutritional status of a large group of air-craft workers in southern California (Wiehl, 1942; Borsook, *et al,* 1943; Borsook, 1945; Borsook, *et al,* 1946; Borsook and Wiehl, 1946). They used dietary records, physical examinations, blood tests, and vitamin supplementation to evaluate nutritional status. In another study reported in 1942, Schnedorf, *et al,* used dietary ratings, physical examinations, and blood tests in a vitamin survey of industrial workmen. More recently, Trulson, *et al,* (1949) have reported the food intakes of low income male and female industrial workers.

Data for the study reported here were gathered from 610 male industrial workers employed in four chemical and pharmaceutical plants in central New Jersey during the period December, 1948, to November, 1950, inclusive. No data were collected during the summer months. The subjects were men who reported for routine physical examinations and who consented to participate in this study. As most of the men gave their consent, the sample studied is considered to be essentially a random sample representative of the male employees of these companies. The study included (1) a record of the usual food

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intake, obtained by a thirty-minute interview with each subject, (2) a seven-day food consumption record kept by each subject (318 subjects only), (3) analysis of the blood for hemoglobin and serum for carotene, vitamin A, and ascorbic acid, and (4) a special physical inspection by a physician for signs of nutritional deficiencies. The methods used have been described elsewhere (Northeast Region, 1951).

Because this research was part of the NE-4 cooperative regional study on nutritional status, much of the data on physical signs, dietary findings, and blood findings have been compared to similar data from other population groups in a series of regional bulletins (Babcock, *et al,* 1952; Tucker, *et al,* 1952; Clayton, *et al,* 1953; Babcock, *et al,* 1953). In this paper the various types of data pertaining to industrial workers have been brought together, additional data have been integrated, the data have been tabulated in a different manner, and the findings have been interpreted from the viewpoint of industrial nutrition.

Tabulation of Data

To summarize the data, it was necessary to classify them into arbitrarily defined groups. The classifications used in this paper were made as follows:

Weight Rating. Although the height-weight relationship is not the best criterion for overweight and underweight, it was applied here as a rough measure because of its simplicity. Weights within 10 pounds of those given in the Medico-Actuarial Investigations of 1912 (Davenport, 1923) were rated as normal.

General Appearance. Rated by the physician as good, fair, or poor physical appearance.

Work. Rated by the interviewer as sedentary, physically active, or very active.

Income Level. Since the income available for the purchase of food is dependent on the total income of the household and the number of persons in the household, the income rating was determined by dividing the weekly household income, in dol-

lars, by the total of adult units. The values for adult units were approximated from the values given by Stiebeling and Clark (1939) for food-expenditure units as follows:

		Adult Units
Man		
	Very Active	1.1
	Physically Active	1.0
	Sedentary	0.9
Woman		0.9
Child		0.7

Educational Level. Grade in school, or its equivalent as other formal education.

Religion. Classified as Catholic, Jewish, or Protestant because some of the data were collected during fasting periods.

Ethnic Group. Dietary patterns were dominantly American, but in many cases they were influenced by the race or nationality of one or more members of the household. Such influence was tabulated according to the ethnic groups listed in Table 3.

Dietary Ratings. Quantities of nutrients, calculated from each dietary history and record, equal to or greater than the National Research Council Recommended Dietary Allowances (1948) for a physically active man, were rated as "high." As the Recommended Dietary Allowances do not have any fixed relationship to the minimum requirement, values more closely approximating the theoretical minimum requirements were chosen as a dividing line between the "moderate" and the "low" ratings. The values, based on the discussion accompanying the 1948 revision of the Recommended Dietary Allowances, which were arbitrarily selected to define the lower limits of the "moderate" group are shown in Table 1.

In the results presented in this paper, no attempt was made to adjust the dietary ratings for differences in the subject's activity because it was questionable whether activity should be based on the interviewer's estimate, the caloric intake calculated from the interview data, or the caloric intake calculated from the seven-day food record.

Nutrient	High	Moderate	Low
Protein, Grams	70 and Over	40 to 70	Less Than 40
Calcium, Grams	1.0 and Over	0.7 to 1.0	Less Than 0.7
Phosphorus, Grams	1.5 and Over	1.0 to 1.5	Less Than 1.0
Iron, Mg.	12 and Over	8 to 12	Less Than 8
Vitamin A, I.U.	5,000 and Over	3,000 to 5,000	Less Than 3,000
Thiamine, Mg.	1.5 and Over	0.7 to 1.5	Less Than 0.7
Riboflavin, Mg.	1.8 and Over	1.0 to 1.8	Less Than 1.0
Niacin, Mg.	15 and Over	7.5 to 15	Less Than 7.5
Ascorbic Acid, Mg.	75 and Over	25 to 75	Less Than 25

Table 1. Levels of various nutrients used for rating dietary histories and records.

Vitamin Supplements. Nutrients taken in tablet form were not included in the calculation of dietary data, but they were tabulated separately. A subject was listed as receiving a vitamin supplement if the quantity consumed provided a daily average of more than 20 per cent of the Recommended Daily Allowance for any of the five vitamins included in this study.

Blood Chemistry Ratings. The following ratings, based on those given by Bessey and Lowry (1947), were used:

	High	*Moderate*	*Low*
Vitamin A (micrograms per 100 ml. serum)	30 and Over	20 to 30	Less than 20
Carotene (micrograms per 100 ml. serum)	120 and Over	80 to 120	Less than 80
Ascorbic acid (mgm. per 100 ml. serum)	0.7 and Over	0.4 to 0.7	Less than 0.4
Hemoglobin (grams per 100 ml.)	14 and Over	12 to 14	Less than 12

Physical Inspection Ratings. The physical inspections were based on a modification of the form published by Sandstead and Anderson (Northeast Region, 1951). The terms used are given in Table 7. To simplify the table, signs rated only as "absent" or "present" have been included in the columns headed "normal" and "moderate," respectively.

Composite Physical Rating. The analysis of the physical data was complicated by the large number of individual signs recorded. As a preliminary method of screening the data, it was decided to combine the physical ratings into a composite

rating for each of the five vitamins studied. Since there was no way of determining the relative importance of each sign, the simple expedient of adding the individual ratings was adopted. The clinical signs suggestive of each vitamin deficiency were based on the list by Jolliffe and Alpert (1947), and they were scored 0 if normal or absent, 1 if mild, 2 if moderate or "present," and 3 if severe. If the total score for a vitamin were 0 or 1, a composite physical rating of "high" was assigned, if 2 or 3, "moderate," and if 4 or more, "low." The list of clinical signs and possible scores for each are given below:

		Possible Score
Vitamin A:		
	Blepharitis	0, 1, 2, or 3
	Palpebral conjunctiva, inflammation	0, 1, 2, or 3
	Bulbar conjunctiva, thickening	0, 1, 2, or 3
	Acne	0, 1, 2, or 3
	Xerosis	0, 1, 2, or 3
	Folliculosis	0, 1, 2, or 3
Thiamine:		
	Neurological Findings—	
	Subnormal knee jerk response	0 or 2
	Subnormal ankle jerk response	0 or 2
	Subnormal vibratory sense	0 or 2
	Calf tenderness	0 or 2
Riboflavin:		
	Blepharitis	0, 1, 2, or 3
	Bulbar conjunctiva, increased vascularity	0, 1, 2, or 3
	Outer canthi, lesions	0, 1, 2, or 3
	Nasolabial seborrhea	0, 1, 2, or 3
	Acne	0, 1, 2, or 3
	Cheilosis	0, 1, 2, or 3
	Tongue, magenta	0 or 2
	Tongue, changes in papillae	0, 1, 2, or 3
Niacin:		
	Palpebral conjunctiva, inflammation	0, 1, 2, or 3
	Stomatitis (buccal mucosa)	0, 1, 2, or 3
	Tongue, red	0 or 2
	Tongue changes in papillae	0, 1, 2, or 3
	Tongue, swelling	0 or 2
	Dermatitis	0 or 2
Ascorbic acid:		
	Gingivitis	0, 1, 2, or 3
	Perifollicular petechiae	0 or 2
	Purpura	0 or 2

Over-All Vitamin Rating. Metcoff, *et al* (1945), have emphasized that no one symptom, sign, or laboratory finding is

pathognomonic for a nutritional deficiency and the various kinds of data suggestive of inadequate nutrition must be interpreted together and evaluated as a whole *for each individual.* While this point is widely recognized, there is no generally accepted scheme for integrating such diverse data. Metcoff, *et al,* used a purely arbitrary procedure suitable to their data. We, likewise, have set up an arbitrary method of rating adapted to the types of data collected in our study. It is recognized that, as with our composite physical rating, there is no sound basis for evaluating the relative importance of each component of the rating. Each subject's dietary, blood, and composite physical ratings for a vitamin were, therefore, weighted equally by assigning numerical values ("high" = 3, "moderate" = 2, and "low" = 1) to each and averaging the numerical values. An average of 2.0, or lower, was arbitrarily used to classify the subject as having suboptimal nutritional status with respect to that vitamin. The only dietary ratings used in this procedure were those derived from the dietary history interviews because seven-day food consumption records were available for only about one-half of the subjects. The only blood ratings used were those for serum vitamin A and ascorbic acid because the other constituents determined, hemoglobin and serum carotene, are only indirect measures of vitamin status.

Results

Characteristics of the Sample. The sample studied has been

Table 2. Distribution of subjects studied by age, activity and religion.

Age of Subjects		Work Rating		Religion	
Years	Per Cent of Total	Activity	Per Cent of Total		Per Cent of Total
Total (606)	100	Total (610)	100	Total (543)	100
20–29	27	Very Active	35	Catholic	46
30–39	45	Physically Active	48	Protestant	52
40–49	17	Sedentary	17	Jewish	1
50–59	7				
60–69	3				

described briefly in the introduction. The data in Tables 2 and 3 show that this sample contained a large proportion of men from 20 to 40 years of age, mostly engaged in moderate to very active work. The incomes and educational levels of these men covered a wide range. Their religious affiliation was approximately equally divided between Catholic and Protestant. The food habits of one-third of the men were probably influenced by a Slavic background, and smaller fractions by Negro, Italian, and German customs.

Dietary Findings. Quantitative estimates of usual food consumption were obtained by a trained nutritionist in a thirty-minute interview with each subject. Typical empty dishes, spoons and, when necessary, photographic and wooden food models were used to help the men judge serving sizes. In addition, each worker was instructed to keep a quantitative record of his actual food consumption during the next seven days. Fifty-two per cent (318 subjects) completed their seven-day records.

Caloric intakes calculated from the dietary interview data averaged 2,988 for the sedentary group, 2,915 for the phys-

Table 3. Distribution of subjects studied by income, education and ethnic group.

Weekly Income		Educational Level		Ethnic Group	
Dollars Per Adult Unit	Per Cent of Total	Grade Completed or College Years	Per Cent of Total	Group	Per Cent of Total
Total (533)	100	Total (605)	100	Total (588)	100
5–9	2	Less Than 8	16	American	39
10–14	13	8	16	English	3
15–19	26	9 or 10	18	German	5
20–24	19	11	6	Italian	9
25–29	14	12	26	Scandinavian	1
30–34	10	College–1	5	Slavic	32
35–39	4	2	4	Negro	9
40–44	2	3	1	Miscellaneous	1
45–54	5	4	7		
55–64	5	M.S.	1		

ically-active group, 3,259 for the very active group, and 3,053 for all groups (606 subjects). Corresponding values from the seven-day food records were 2,709, 2,739, 2,785, and 2,746 calories for the entire group (318 subjects).

The tendency for higher intakes to be recorded in dietary history interviews, as compared with those in the seven-day food consumption records kept by the subjects, may have been caused by several factors. They include:

1. Differences in the samples studied.
2. Over-estimation in the interviews.
3. Under-estimation in the seven-day records.

Differences in the overlapping samples of men who supplied the history and seven-day record data were noted in their educational levels, incomes, and dietary histories. The men who kept dietary records for seven days had, on the average, a higher educational level (eight months more schooling), a slightly higher income level (an average of $1.80 more family income per week), and slightly lower dietary history values than the larger group of men who supplied the dietary history

Table 4. Comparison of dietary histories and seven-day dietary records of 318 men.

	Mean History	Mean Record	Mean Difference	Standard Error of Difference	Per Cent Difference
Calories	2,909.	2,745.	+164.**	38.7	5.98
Protein, Gm.	93.5	90.0	+3.5**	1.33	3.84
Calcium, Gm.	1.130	.934	+.196**	.0240	20.97
Phosphorus, Gm.	1.731	1.559	+.172**	.0256	11.02
Iron, Mg.	16.96	16.12	+.84**	.266	5.20
Vitamin A, I. U.	10,470.	8,240.	+2,230.**	303.	27.04
Thiamine, Mg.	1.600	1.545	+.055*	.0258	3.57
Riboflavin, Mg.	2.317	2.005	+.312**	.0397	15.58
Niacin, Mg.	20.2	19.6	+.6*	.32	3.32
Ascorbic Acid, Mg.	102.6	77.1	+25.5**	2.48	33.22

** Difference significant at the 1 per cent level.
* Difference significant at the 5 per cent level.

data. The last comparison is based on means given in Table 4 and means previously published (Tucker, et al, 1952).

To determine whether other factors than sample differences were involved, a further study was made in which sample differences were eliminated by restricting the analysis to those subjects who supplied both types of dietary information. Although significant differences were still found between the means obtained by the dietary history and the seven-day record for all nutrients, the percentage differences were small (3 per cent to 6 per cent) for calories, protein, iron, thiamine, and niacin (Table 2). The larger percentage differences obtained for calcium, phosphorus, vitamin A, riboflavin, and ascorbic acid show that other factors, such as estimation errors, must also have contributed to the higher values obtained by the dietary history method for these nutrients. Somewhat greater differences had been noted in a previous analysis (Young, *et al.*, 1952, a, b) based on a portion of these same data gathered early in the study.

Errors in dietary estimation may involve both the size and frequency of food servings. There is a general tendency to overestimate the size and to underestimate the frequency (because of omissions). (Young, *et al,* 1952 b, 1953). A review of the original records suggested that the overestimation of serving sizes may have been greater in the interviews (because of a tendency of the men to make a good impression) than in the seven-day records. In keeping the seven-day records, the men frequently had an opportunity to check their estimates by measuring the serving sizes, or they may have had help from their wives, who were probably more experienced in judging food quantities.

Underestimation of the frequency of servings in the seven-day records may have occurred because of omissions as the subjects' enthusiasm for keeping the records declined, despite the generally cooperative attitude of the workers. A few of the records appeared to be less complete the last few days of the week. Omissions from the dietary histories on the other hand,

were largely avoided by the cross-check (Northeast Region, 1951), and in some cases there seemed to be a tendency to overestimate rather than underestimate the frequency of servings in the histories. For example, there was a tendency for the men to say they had certain amounts of milk and vegetables *every day*, when it is more probable that they consumed that much most days, and less on other days. Overestimation of these foods in the dietary histories would largely account for the higher history values for calcium, phosphorus, vitamin A, riboflavin, and ascorbic acid.

In view of the foregoing observations on sample differences, probable overestimation in the dietary histories, and underestimation in the seven-day records, the best estimate of the average dietary intake of this group of workers is thought to lie somewhere between the values obtained by the histories and the seven-day records.

Table 5 lists the per cent of subjects who had "high," "moderate," and "low" intakes of each nutrient, as calculated from both the histories and seven-day records. Means and standard deviations of the intakes have been given elsewhere (Tucker, *et al*, 1952). Most striking is the observation that about one-fourth of the men had low intakes (less than 0.7 gm. per day)

Table 5. Per cent of subjects in each dietary rating.

	Dietary Rating					
	Dietary History (606 Subjects)			7-Day Food Record (318 Subjects)		
	High	Moderate	Low	High	Moderate	Low
Protein	87	13	0	83	17	0
Calcium	54	27	18	39	30	31
Phosphorus	68	30	3	54	41	5
Iron	91	9	0	87	13	0
Vitamin A	92	8	1	75	22	3
Thiamine	62	39	0	49	50	1
Riboflavin	74	25	1	58	40	3
Niacin	86	14	0	80	19	1
Ascorbic Acid	71	28	0	46	50	4

of calcium. Furthermore, if the lower level of 0.5 gm. of calcium is considered, both kinds of dietary data showed that one out of every eighteen men consumed less than that amount per day. A study of over 100 dietary histories, selected to represent all age, income, and educational levels, showed that low calcium intakes occurred somewhat more frequently with men who had low incomes and also with men who had only grammar school educations. (Babcock, *et al,* 1954). These groups of men ate relatively less of their calories in the form of milk and dairy products than men with higher income and educational levels. In all groups, however, there was wide individual variation in milk consumption; an average of 30 per cent of the men consumed less than one cup of fluid milk per day, while 11 per cent drank a quart or more per day. Surprisingly, the breakfast habits of the men had little effect on their total milk consumption (Gates, 1954). The relative contributions of fluid milk, bread and potatoes to the nutritive values of the diets has been reported elsewhere (Steele, *et al,* 1954).

Low milk consumption by a number of the men explains why a relatively high proportion of the diets did not meet the National Research Council's recommended allowances for calcium, phosphorus, and riboflavin. Thiamine and ascorbic acid intakes were also frequently below the recommended levels (Table 5). Although the men consumed relatively large amounts of meat and enriched bread, their high consumption of unenriched bread and pastries, sweetened beverages, and candy bars probably explains the low thiamine values. The low ascorbic acid intakes frequently observed were ascribed to low consumption of leafy green vegetables and, in some cases, low consumption of citrus fruits and tomatoes. A study of 122 dietary histories revealed that only one-eighth of the men ate one serving or more of leafy-green and yellow vegetables per day and three-fourths had one serving of citrus fruit per day. Potatoes supplied about one-seventh of the total intake of ascorbic acid.

These group findings were confirmed by a separate examination of all the data for each individual. Each subject was given

a report which included a description of the basic seven food groups (United States Department of Agriculture, 1946) and specific recommendations for improving his nutritional status, based on his dietary, blood, and physical findings. No change in diet was indicated for one-fifth of the men, but half of them were advised to increase their consumption of dairy products and fruits and vegetables rich in ascorbic acid. One-fourth of the men were advised to reduce their consumption of sugars and starches.

Vitamin supplements, as previously defined, were taken by 7 per cent of the workers. These forty-one men had considerably higher blood levels of ascorbic acid, but they had more gingivitis, thickening of the bulbar conjunctiva, and changes in the tongue papillae than the men who did not take vitamin supplements. Since these two samples of men, with and without vitamin supplements, were not comparable with respect to education, income, and ethnic groups, the physical signs may be related to other dietary, medical, or environmental factors, rather than to the consumption of vitamin supplements.

Blood Findings. The per cent of subjects in each blood chemistry rating is given in Table 6. More detailed studies of the distributions are given elsewhere (Clayton, *et al*, 1953). The data for ascorbic acid confirm the dietary findings in showing that relatively high percentages of the men failed to meet the recommended standards. The blood vitamin A values were high (in agreement with the dietary history findings), but the carotene levels were relatively lower.

Physical Findings. Eighty-six per cent of the subjects were

Table 6. Per cent of subjects in each blood chemistry rating.

	Blood Chemistry Rating		
	High	Moderate	Low
Vitamin A (595 Subjects)	94	5	1
Carotene (597 Subjects)	60	31	10
Ascorbic Acid (606 Subjects)	47	30	24
Hemoglobin (596 Subjects)	87	11	2

rated by physicians as having "good" general appearance, 14 per cent were rated "fair," and none "poor." However, 44 per

Table 7. Per cent of subjects in each physical inspection rating (607 subjects).

	Physical Inspection Rating			
	Normal or Absent	Mild	Moderate or Present	Severe
Eyes:				
Blepharitis	95	5	0	0
Palpebral Conjunctiva, Inflammation	90	9	1	0
Bulbar Conjunctiva, Increased Vascularity	77	20	3	0
Bulbar Conjunctiva, Thickening	89	9	1	1
Outer Canthi, Lesions	97	3	0	0
Skin: Face—				
Nasolabial Seborrhea	93	5	2	0
Acne	97	2	1	0
Lips:				
Cheilosis (Including Angular Stomatitis)	86	12	2	0
Buccal Mucosa:				
Stomatitis	96	3	1	0
Gums:				
Gingivitis	79	10	8	3
Tongue:				
Color—	94	—	–	–
Reddened	—	—	4	–
Magenta	—	—	2	–
Papillae, Changes in	88	4	8	0
Swelling	97	—	3	–
Fissuring	93	4	3	0
Thyroid (Goiter):	100	0	0	0
Neurological Findings:	97	—	3	–
Skin—General:				
Dermatitis	96	—	4	–
Xerosis	91	5	3	1
Perifollicular Petechiae	97	—	3	–
Folliculosis	93	4	2	0
Purpura	100	—	0	–
Atrophy	98	1	0	0

cent were overweight by 10 pounds or more, and 21 per cent were underweight by that amount. The characteristics of the overweight group were nearly the same as those given in Tables 2 and 3 for all subjects. That is, there was no clear tendency for overweight to occur more frequently in any particular age, work, income, educational, religious, or ethnic group. An analysis of the dietary, blood, and physical findings from the overweight group will be reported separately.

The data in Table 7 show that gingivitis and increased vascularity of the bulbar conjunctiva were each observed in one-fifth of the subjects. Cheilosis, changes in the papillae of the tongue, thickening of the bulbar conjunctiva, and inflammation of the palpebral conjunctiva were observed in one-tenth of the men. The various physical signs observed for each individual were considered together in formulating the composite physical ratings for each nutrient, as described in the Tabulation of Data. The percentages of subjects assigned each rating are listed in Table 8. Except for thiamine and ascorbic acid, the physical findings are in general agreement with the dietary and blood findings. The use of neurological findings as the sole physical criterion of thiamine deficiency did not provide a sensitive test for that nutrient. The procedure for calculating the ascorbic acid composite physical rating made this rating also a conservative one.

Over-All Vitamin Ratings. As defined in the Tabulation of Data, these ratings were used to arbitrarily classify the nutritional status of each subject on the basis of a combination of

Table 8. Per cent of subjects in each composite physical rating (607 subjects).

	Composite Physical Rating		
	High	Moderate	Low
Vitamin A	85	12	3
Thiamine	97	2	0
Riboflavin	76	19	5
Niacin	83	11	5
Ascorbic Acid	86	14	0

Age Group		Work Activity		Religion	
Years	Per Cent of Total	Rating	Per Cent of Total	Religion	Per Cent of Total
Total (157)	100	Total (158)	100	Total (158)	100
20–29	27	Very Active	42	Catholic	31
30–39	38	Active	43	Protestant	66
40–49	24	Sedentary	15	Jewish	4
50–59	8				
60–69	4				

Table 9. Distribution of subjects having suboptimal ratings for one or more vitamins according to age, physical activity, and religion.

his dietary, blood, and physical findings. Suboptimal ratings were found, for one or more vitamins, in 26 per cent (158 subjects) of the sample. Of these 158 subjects, one had a suboptimal rating for vitamin A, ten for thiamine, fifty-eight for riboflavin, forty-five for niacin, and eighty-four for ascorbic acid.

Characteristics of the group of subjects classified as having suboptimal nutrition for one or more vitamins are given in Tables 9 and 10 for comparison with the characteristics of the entire sample (Tables 2 and 3). The figures are generally simi-

Table 10. Distribution of subjects having suboptimal ratings for one or more vitamins according to income, education and ethnic group.

Weekly Income		Educational Level		Ethnic Group	
Dollars Per Adult Unit	Per Cent of Total	Grade Completed or College Years	Per Cent of Total	Group	Per Cent of Total
Total (138)	100	Total (156)	100	Total (158)	100
5–9	4	Less than 8	18	American	34
10–14	14	8	19	English	3
15–19	31	9 or 10	20	German	8
20–24	13	11	9	Italian	10
25–29	14	12	23	Scandinavian	2
30–34	7	College 1	4	Slavic	27
35–44	4	2 or 3	2	Negro	14
45–54	9	4	6	Miscellaneous	3
55–64	4	M.S.	0		

lar except that the suboptimal group included slightly higher percentages of Protestants, men over 40 years of age, men with low incomes, men doing very active work, and Negroes; and slightly lower percentages of men with advanced educations. A critical analysis of these findings will be published separately (Babcock, *et al*, 1954).

Discussion

Individually the dietary, blood, and physical findings were generally in agreement in showing that nutritional status was lower than the optimum standards for many subjects (roughly 20 per cent to 30 per cent for most of the nutrients).

It is widely recognized that each of the above measures of nutritional status is subject to certain errors and may, by itself, be an unreliable index. Pett (1945) has emphasized that the *normal* distribution of values from a healthy population will include many values lower than the usual standards, which are set high enough to meet the needs of most of the individuals in a population. A combination of dietary, chemical, and medical evaluations for each individual should provide a more reliable index of nutritional status. The arbitrarily defined overall vitamin ratings used here are one of many such combined measures that might be devised to provide indexes of nutritional status. It is recognized that any changes in the basis for the ratings, such as using the seven-day records instead of the dietary interview data, using other standards for defining the "high," "moderate," and "low" groups, or weighting the medical signs differently, might make a considerable difference in the number of subjects rated as having suboptimal nutritional status. Nevertheless, in the absence of any generally accepted procedure for integrating such diverse types of nutritional survey data, these ratings provide a basis for summarizing the data and assist in its evaluation. The finding that one-fourth of the subjects had suboptimal overall vitamin ratings confirms the separate dietary, blood, and physical findings for the group and is also consistent with the recommendations made to each subject on the basis of his individual findings.

It should be noted that this study was limited to men who were physically fit to work and had steady employment in large chemical and pharmaceutical companies. Each company had a cafeteria and at least one full-time plant physician. The study was made following the World War II period of nutrition education and adoption of the enrichment program.

Data given here and in other reports of this study lead to the following generalizations concerning the nutritional status of this group of industrial workers.

(1) No cases of acute nutritional deficiency diseases were observed.

(2) About one-fourth of the men gave some evidence of suboptimal nutrition with respect to one or more nutrients, particularly for calcium, phosphorus, thiamine, riboflavin, and ascorbic acid.

(3) Suboptimal nutrition and also obesity were observed widely throughout all education, age, income, and ethnic groups.

(4) Dietary faults frequently observed were low consumption of milk and vitamin C-rich vegetables and fruits, and high consumption of unenriched bread and pastries, sweetened beverages, and candy bars.

(5) Inadequate breakfasts and between-meal snacks of sweet foods frequently were contributing causes of unbalanced diets.

The practical implications of these findings are that measures should be taken to improve the nutrition of industrial workers by making appetizing, nutritious foods available to them at eating times and by emphasizing the desirability of selecting adequate diets. This nutrition program should be directed to all workers, rather than restricting it to certain education, age, or income groups.

The practical aspects of industrial nutrition have been discussed by others (United States Department of Agriculture, 1945; *Nutrition Reviews,* 1953; New Jersey Department of Health, 1949).

Summary

Dietary, blood, and physical findings from 610 male industrial workers have been evaluated to characterize the nutritional status of that group. The evaluation has been based on individual findings for dietary nutrients, blood constituents, and physical signs, and also collectively on arbitrary combinations of these three measures for each subject.

About one-fourth of the men gave some evidence of suboptimal nutrition with respect to one or more nutrients. The dietary weaknesses observed and the practical implications of these findings have been discussed.

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