NUTRITIONAL STATUS OF INDUSTRIAL WORKERS[1,2]

II. EFFECTS OF EDUCATION, AGE, INCOME, AND ETHNIC GROUPS

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INTRODUCTION

IN the previous paper of this series (Babcock, *et al,* 1954) an arbitrary procedure was used to classify the nutritional status of 600 male industrial workers on the basis of their individual dietary, blood, and physical findings. The characteristics of the group classified as having suboptimal nutrition with respect to one or more vitamins were then compared to the characteristics of the entire sample. The characteristics were generally similar, but the suboptimal group included slightly higher percentages of 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.

Results such as these, in which nutritional status appears to be related to various factors, are difficult to evaluate because many variables may be affecting the results simultaneously. For example, the finding that men with advanced education had better nutritional status might have been caused by more intelligent selections of diets, or it might be that, having higher incomes, these men could afford more of the protective foods. In this paper an attempt is made to evaluate separately the effects of education, age, and income on nutritional status by studying samples that are comparable with respect to major variables other than the one under study. Observations are also made on the effects of food habits of different ethnic groups on nutritional status.

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Control of Extraneous Variation

Ideally, all variables should be controlled except the one under study. The following variables have frequently been considered in nutritional surveys (National Research Council, 1943): Sex, age, education, occupation, income, family size, ethnic group, size and type of community, geographic region, year, season, and reliability of data collected by various techniques. In the study reported here, variation due to sex, occupation, size and type of community, and geographic region were largely avoided by restricting the sample to male industrial workers employed in chemical and pharmaceutical plants located in industrial communities in central New Jersey. Yearly and seasonal variations were limited by restricting the collection of data to a two-year period (1949–1950) in which wages and food prices were relatively stable, and by making no studies during the summer months. Variation in family size was assumed to have its effect largely on the income available for buying food, and was, therefore, considered in defining the income groups. Variation in education, age, income, and ethnic groups were controlled by selecting samples equally represented, so far as possible, with respect to these variables (except for the variable being studied). Variation in the reliability of the data was minimized by using the same techniques throughout (Northeast Region, 1951).

Education Effect

Selection of Comparable Samples. To determine whether the previously noted variation of nutritional status with educational level was directly associated with the educational levels or indirectly with other variables, samples comparable with respect to other variables listed above were selected for each of the following four different educational levels: 8th grade or less; 9th, 10th, and 11th grades; high school graduates; and one or more years of advanced education. These groupings provide a measure of the general education of the workers, but do not specifically indicate the amount of education in nutrition that

either the workers or their wives had. To obtain comparable samples the number of subjects in each educational group was reduced as necessary to leave samples with equal percentages (± 1 per cent) of men age 20–29, with equal percentages of men age 30–39, and with equal percentages of men age 40–69 in each educational group. Concomitant with this adjustment, the number of subjects in each of these educational groups was reduced as necessary to leave samples with equal percentages (± 1 per cent) of men with low income, equal percentages with moderate income, and equal percentages with high income in each educational group. The income classifications were based on the household income, modified for family size, as previously defined (Babcock, *et al,* 1954). For example, a physically active man and wife whose total income was between $38 and $57 per week, were classified as having moderate income. In reducing the numbers of subjects to obtain samples represented equally with respect to age and income distributions, care was taken to maintain approximately the same proportions of each ethnic group in the different samples. The representative samples chosen in this manner were then further checked to establish that they had approximately the same percentages of subjects in each work activity group (sedentary, physically active, or very active). Because of the limited number of subjects, it was not always possible to have the samples completely unbiased with respect to each of these variables. The exceptions which might be significant were as follows:

a. The highest education group included no Negroes, in contrast to 7–10 per cent Negroes in the other groups.

b. With increasing educational level the proportion of very active workers decreased from 54 per cent to 21 per cent. The advanced education group had 48 per cent sedentary workers compared to 5–13 per cent for lower educational levels.

Results. When the effects of age, income, etc. were removed by selecting samples comparable with respect to these variables, the variation in percentages of subjects classified as having

	8th Grade or Less (93 Subjects)			9, 10, 11th Grade (95 Subjects)			High School Graduates (60 Subjects)		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
Protein	90	9	1	82	18	0	85	15	0
Calcium	47	33	21	52	27	21	55	27	18
Phosphorus	64	33	3	63	34	3	68	30	2
Iron	91	18	1	85	15	0	82	18	0
Vitamin A	85	4	1	94	4	2	93	7	0
Thiamine	67	33	1	59	41	0	62	38	0
Riboflavin	73	26	1	63	36	1	73	27	0
Niacin	88	12	0	84	16	0	90	10	0
Ascorbic Acid	71	29	0	70	30	0	75	23	2

Table 1. Percentage of subjects in each dietary rating based on the dietary histories.

suboptimal nutrition was less pronounced than had been observed in the total sample. Only the highest educational level remained appreciably different from the others. Of the men who had one or more years of education beyond high school, 14 per cent (8 subjects) were classified as having suboptimal nutrition with respect to one or more vitamins in contrast to 27–30 per cent for men who had less education.

As the above classification of nutritional status is an arbitrary one based on part of the dietary, blood, and medical data from each subject, it is of interest to analyze each of these types of data separately to determine which, if any, were associated with educational level. The dietary history as obtained by interview, the blood analyses, and the physical findings are discussed in the following paragraphs.

Dietary Findings. Caloric intakes and their standard deviations calculated from the dietary histories for each educational group were as follows:

8th Grade or Less	3,108 ± 868. Calories
9th, 10th, and 11th Grades	2,983 ± 886. Calories
High School Graduates	3,047 ± 870. Calories
One or More Years of Advanced Education	3,079 ± 726. Calories

The percentage of subjects in each dietary rating, as pre-

Advanced Education (56 Subjects)		
High	Moderate	Low
93	7	0
61	30	9
73	27	0
98	2	0
95	5	0
59	41	0
88	12	0
82	18	0
77	23	0

viously defined (Babcock, *et al,* 1954) is given in Table 1. These data show that nutrient intakes, as measured by the dietary histories, were generally similar for all educational levels, but that high intakes of calcium, phosphorus, vitamin A, and riboflavin occurred somewhat more frequently in the higher education groups.

To provide further information on the effects of education on dietary habits a study was made of the consumption of certain food groups. Random samples of the dietary histories from each of the four education samples in this study were used. Table 2 gives the average contribution of each food group to the total caloric intake for each educational level. There was some tendency for the consumption of dairy products to increase, and for starchy foods to decrease as the educational level increased, but the differences were small and not entirely consistent.

Blood Findings. The percentage of subjects in each blood chemistry rating, as previously defined (Babcock, *et al,* 1954) is given in Table 3. These data indicate that blood levels of vitamin A and hemoglobin were generally similar for all educational levels, but that high serum levels of carotene and as-

Table 2. Percentage of the total caloric intake supplied by several food groups.

	8th Grade or Less (32 Subjects)	9, 10, 11th Grade (32 Subjects)	High School Graduates (30 Subjects)	Advanced Education (28 Subjects)
Fluid Milk	7.8	11.0	10.9	10.8
Milk Products[1]	2.8	3.3	4.1	2.5
Total Dairy[1]	10.6	14.3	15.0	13.3
Bread	16.0	11.7	12.4	11.4
Sweet Rolls	0.8	1.2	1.3	0.7
Total Breadstuffs	16.8	12.9	13.7	12.1
Potatoes	8.1	7.0	8.5	6.5

[1] Excluding butter.

	8th Grade or Less (93 Subjects)			9, 10, 11th Grade (94 Subjects)			High School Graduates (57 Subjects)		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
Vitamin A	92	6	1	95	3	1	97	4	0
Carotene	56	34	10	69	20	10	72	23	5
Ascorbic Acid	39	33	28	42	34	24	47	32	22
Hemoglobin	84	13	3	87	12	1	84	10	5

Table 3. Percentage of subjects in each blood chemistry rating.

corbic acid occurred with increasing frequency as the educational level increased.

Physical Findings. The frequencies of twenty-two individual clinical signs possibly related to nutritional status (Babcock, *et al,* 1952) were generally similar for all educational levels. Men with advanced education, however, had less gingivitis (13 per cent) than men in the other groups (22 per cent to 26 per cent).

To relate the individual physical findings to nutrients, they were combined by an arbitrary procedure into composite physical ratings, as previously described (Babcock, *et al,* 1954). The percentages of subjects having each composite physical rating are given in Table 4. The frequencies with which the examining physicians rated the subjects' general physical appearance as good, fair, or poor, and the incidence of underweight and overweight, are also listed in this table. These data show that the physical ratings of nutritional status were generally similar for all educational groups, but that high ratings occurred with slightly greater frequency in the higher education groups for vitamin A, niacin, and ascorbic acid. Overweight (by 10 lbs.) was found most frequently in men who had the equivalent of 9 to 11 years of formal education.

Statistical Analysis. The dietary, blood, and physical data agreed in showing that the nutritional states of the four educational groups were generally similar, but that with several measures there was a tendency toward higher nutritional status as

Advanced Education (56 Subjects)		
High	Moderate	Low
92	7	0
76	20	4
60	20	20
89	9	2

the education level was increased. Where numerical (dietary and blood) data were available, such tendencies for correlation of nutritional status with educational level were analyzed statistcially. Correlation analyses were made using the same 300 men, but they were further divided into each number of years of schooling, ranging from less than 8th grade (counted as 7 years of schooling) to Ph.D. (counted as 19 years of schooling). The nutrient levels were also divided into ten or more small groups for this analysis. For the dietary history data discussed in connection with Table 1, the correlation coefficients were: calcium, 0.236; phosphorus, 0.169; vitamin A, 0.027; and riboflavin, 0.105. For blood carotene and ascorbic acid (*cf.* Table 3) the correlation coefficients were 0.051 and 0.139, respectively. These coefficients confirm the frequency tabulations in showing a slight positive correlation of educational level with certain measures of nutritional status. The correlation coefficients are relatively low, however; only those for calcium and phosphorus are significant at the 1 per cent level, and only blood ascorbic acid at the 5 per cent level. Also, for the advanced education group, the tendency of the blood and physical findings to indicate better nutritional status may have been caused in part by a higher consumption of vitamin supplements. Twelve per cent of this group took vitamin supplements in contrast to 3–5 per cent for the other educational groups.

Age Effect

Selection of Comparable Samples. A study of the effect of age level on nutritional status was set up directly analogous to the study of the education effect. Samples comparable with respect to education, income, and ethnic groups were selected for three age groups, 20–29, 30–39, and 40–69 years. These three samples were also comparable in other characteristics.

Results. The percentage of subjects classified as having sub-

Table 4. Percentage of subjects in each composite physical rating, physical appearance rating and weight rating.

Composite Physical Rating	8th Grade or Less (93 Subjects)			9, 10, 11th Grade (95 Subjects)			High School Graduates (60 Subjects)			Advanced Education (56 Subjects)		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
Vitamin A	80	14	5	87	10	2	90	10	0	87	11	2
Thiamine	99	1	0	98	2	0	97	2	2	97	4	0
Riboflavin	78	16	5	74	21	5	75	20	5	80	18	1
Niacin	80	10	10	84	13	2	85	10	5	87	11	2
Ascorbic Acid	86	13	1	83	17	0	85	15	0	95	5	0
	Good	Fair	Poor	Good	Fair	Poor	Good	Fair	Poor	Good	Fair	Poor
Appearance	86	13	0	84	17	0	84	17	0	85	14	0
	Under-weight	Normal	Over-weight	Under-weight	Normal	Over-weight	Under-weight	Normal	Over-weight	Under-weight	Normal	Over-weight
Weight Rating	20	38	42	19	28	53	22	40	38	23	37	39

optimal nutrition with respect to one or more vitamins was similar for all groups; 28 per cent for age 20–29 and 25 per cent for each of the higher age groups. Inspection of the overall vitamin ratings for each vitamin, however, did show an apparent age effect for ascorbic acid. The percentage rated suboptimal in ascorbic acid increased from 8 per cent to 14 per cent and 18 per cent with increasing age levels.

Because of space limitations, the dietary, blood, and physical findings are not tabulated here by age groups. The dietary history data were generally similar for all age groups, except that men 20 to 29 years of age consumed an average of approximately 200 calories more per day than older men. The greater caloric intake of the younger workers probably accounts for the fact that they had higher frequencies (by about 10 per cent) of men with high nutrient intakes. For thiamine, the difference was larger; 80 per cent high intakes for age 20 to 29 compared to 60 per cent for older men. Correlation analyses of the same 272 subjects, classified into 5-year age groups, showed no significant correlation of age with dietary protein, riboflavin, niacin, or ascorbic acid, but gave a correlation coefficient of -0.165 (significant at the 1 per cent level) for thiamine.

The blood levels of vitamin A, carotene, ascorbic acid, and hemoglobin were similar for all age groups.

The frequency of individual physical signs, except for gingivitis, xerosis and tongue papillae, was similar for all age groups. The incidence of xerosis of the skin and changes in papillae of the tongue were 15 per cent higher in men age 20–29 than in older men. A consistent increase in all degrees of gingivitis

Table 5. Percentage of subjects having different degrees of gingivitis.

	Age 20–29 (65 Subjects)	Age 30–39 (150 Subjects)	Age 40–69 (57 Subjects)
Normal	92	82	72
Mild	5	8	9
Moderate	3	9	12
Severe	0	1	7

	Age 20–29 (65 Subjects)	Age 30–39 (150 Subjects)	Age 40–69 (57 Subjects)
Underweight by 10 Lbs.	25	14	39
Normal Weight	34	37	33
Overweight by 10 Lbs.	41	49	28

Table 6. Percentage of subjects in each weight rating.

with age is shown by the data in Table 5. The composite physical ratings were similar for all vitamins, except ascorbic acid, which reflected the incidence of gingivitis. Men 30 to 39 years of age were relatively heavier than older and younger men (Table 6).

Income Effect

Selection of Comparable Samples. A study of the effect of income on nutritional status was set up directly analagous to the studies of education and age effects. Samples comparable with respect to education, age, and ethnic group were selected for three income groups. The income classifications were based on the household income, modified for family size, as previously defined. The three income samples were comparable with respect to other variables except that the high income group had a higher percentage of sedentary workers (24 per cent vs. 13–15 per cent).

Results. The percentage of subjects classified as having suboptimal nutrition with respect to one or more vitamins was similar for all groups; 28 per cent for the low income group (118 subjects), 23 per cent for the moderate income group (132 subjects), and 27 per cent for the high income group (74 subjects). Inspection of the overall vitamin ratings for each vitamin, however, did show an apparent income effect for ascorbic acid. The percentage rated suboptimal in ascorbic acid decreased from 19 per cent to 12 per cent and 10 per cent with increasing income levels.

Because of space limitations, the dietary, blood, and physical findings are not tabulated here by income group. The dietary history data were generally similar for all income groups,

except that the low income group had low intakes of calcium more frequently (25 per cent vs. 16–17 per cent), and had less men (65 per cent vs. 73 per cent) who received the recommended allowance of ascorbic acid. The blood data showed a similar small difference in ascorbic acid; 41 per cent of the low income group had high serum levels compared to 48 per cent of the other income groups. The composite physical ratings also showed a slightly lower percentage of subjects with high ascorbic acid ratings in the low income group. The moderate income group had a lower incidence (17 per cent) of increased vascularity of the bulbar conjunctiva than the other groups (33 per cent and 30 per cent). The moderate income group had relatively higher body weights; 54 per cent were overweight compared to 40–41 per cent for the other groups and 13 per cent were underweight compared to 25–28 per cent for the other groups.

Since the effects of income on the dietary and blood findings appeared to be limited to the low income group, correlation analyses were not made. The effects of income on the consumption of certain food groups was studied on random samples of the dietary histories from each of the three income samples used in this study. Table 7 shows that low income subjects obtained relatively less of their calories from dairy products and slightly more from bread than did higher income groups.

Table 7. Percentage of the total caloric intake supplied by several food groups.

	Low Income (30 Subjects)	Moderate Income (34 Subjects)	High Income (37 Subjects)
Fluid Milk	8.8	12.4	10.75
Milk Products[1]	2.7	2.8	3.6
Total Dairy[1]	11.4	15.3	14.3
Bread	13.2	11.8	12.0
Sweet Rolls	.6	1.3	.8
Total Breadstuffs	13.9	13.1	12.7
Potatoes	8.1	6.5	7.8

[1] Excluding butter.

Ethnic Effect

The dietary patterns of the industrial workers were dominantly American, but in many cases were influenced by the race or nationality of one or more members of the household. Such influence, recorded during the dietary interview, was used to classify the subjects into ethnic groups. Where no other race or nationality background had an influence, the subjects were classified in the "American" ethnic group, which was then used as a standard for comparing the influence of other ethnic groups.

Because of the small numbers of subjects in some ethnic groups, it was not possible to select ethnic group samples representative with respect to education, age, and income. However, since the above studies have established that education, age, and income had relatively small effects on nutritional status, it is of interest to compare the findings for different ethnic groups, using the total sample in each case.

Results. The proportion of subjects classified as having suboptimal nutrition with respect to one or more vitamins was 23 per cent for the American (reference) group (225 subjects), 40 per cent for Negroes (55 subjects), 41 per cent for Germans (31 subjects), 29 per cent for Italians (48 subjects), and 22 per cent for the Slavic group (185 subjects).

The dietary histories showed similar nutrient intakes for all ethnic groups, except Negroes. The Negroes' average caloric intake ($3{,}344 \pm 960$) was significantly higher than that of the reference (American) group ($2{,}958 \pm 857$). Their greater caloric intake resulted in significantly higher intakes of most other nutrients also. This higher food consumption was associated with a larger proportion (67 per cent vs. 26 per cent) of the Negroes who were engaged in very active work, rather than with overweight, which was more common (41 per cent vs. 29 per cent) in the reference group. Despite significantly higher intakes of ascorbic acid, iron and protein, calculated from the Negroes' dietary histories, their blood analyses showed significantly lower average levels of serum ascorbic acid and hemoglobin. Negroes showed higher incidences of clinical signs pos-

sibly related to deficiencies of riboflavin, niacin, ascorbic acid and vitamin A than the American reference group. The 31 German subjects also had higher incidences of clinical signs possibly related to deficiencies of riboflavin and niacin than the American group. The Italian group had a significantly higher dietary vitamin A intake and higher serum carotene level than the reference group, but also had a higher incidence of clinical signs possibly related to deficiency of riboflavin. Aside from the above-mentioned differences, the dietary, blood, and physical findings were generally similar for the five ethnic groups.

Discussion

Although some extraneous variation could not be avoided, it is felt that the uncontrolled variation remaining after the careful selection of samples probably had little effect on the nutritional status findings.

Increasing the level of general education had an apparently beneficial effect on dietary intakes of calcium, phosphorus, vitamin A, and thiamine, blood serum levels of carotene and ascorbic acid, physical signs possibly related to deficiencies of vitamin A, niacin, and ascorbic acid, and the combined dietary-blood-physical rating for ascorbic acid. However, most of these trends were not consistent throughout all educational levels and, therefore, were not found to be statistically significant in the correlation analyses. Although statistically significant correlation coefficients were found for educational level with dietary calcium and phosphorus, and serum ascorbic acid, these coefficients were so low that they carry little practical significance. Since large numbers of even the highest educational group failed to meet the National Research Council Recommended Dietary Allowances and other standards used in this study, efforts to improve nutrition should be directed to all groups of industrial workers, including men with advanced educations.

Age differences were noted in the larger appetites of men in their twenties, but only the thiamine intake showed a statistically significant decrease over the entire age range, and this

correlation was of low order. Although the incidence and severity of gingivitis increased with age, no appreciable age variation was revealed by the blood findings. Sinclair (1948) has pointed out that, since people without teeth seldom have gingivitis, the apparent incidence of gingivitis will increase and then diminish with age. The general picture is one of similar nutritional status for industrial workers of all ages.

An association between family income and nutritional status was noted only at the low income level. Men in the low income group had slightly lower intakes of calcium due to lower consumption of milk. They also had slightly poorer ascorbic acid nutriture, as revealed by the dietary, blood, and physical findings. It should be noted that all subjects studied had regular incomes; greater effects of income on nutritional status would likely have been observed if the sample had included unemployed families, as in the recent study of pregnant women by Jeans, *et al.* (1952). Our finding that relatively large numbers of even the highest income group failed to meet the standards used in this study confirms the observation of Jeans that "Education in nutritional requirements appears to be even more needed than increase in purchasing power for these families."

Data from unselected samples of subjects classified according to race and nationality suggested that, while the nutritional problems of Negroes may differ slightly from those of other ethnic groups, suboptimal nutrition was observed widely throughout all ethnic groups.

The findings reported here emphasize that industrial nutrition programs should be directed to all workers, rather than restricting them to certain education, age, income, or ethnic groups. Thus, suitable in-plant feeding facilities and nutrition education should be provided for office personnel, as well as for all shifts of workers in a plant.

Summary

Independent effects of education, age, and income on the nutritional status of male industrial workers have been studied by comparing samples selected to be comparable, so far as pos-

sible, with respect to other variables likely to influence nutritional status. Comparisons have been made of dietary intakes, blood levels (vitamin A, carotene, ascorbic acid and hemoglobin), physical signs frequently associated with malnutrition, and arbitrary ratings based on a combination of these three kinds of data for each subject.

Increasing the number of years of schooling slightly improved the nutritional status, as measured by dietary intakes of calcium and phosphorus and serum ascorbic acid. Age appeared to have little effect on the nutritional status of these men, except for a slight decrease in thiamine intakes and increase in gingivitis with increasing years. Low family incomes were associated with low calcium intakes and poor ascorbic acid nutriture.

Although slight differences in nutritional status were attributed to effects of educational level, age, and income, the dominant trend was for evidence of suboptimal nutrition, and also obesity, to be widely distributed throughout all education, age, income and ethnic groups. The practical implications of these findings are that nutrition programs should be directed to all workers, rather than to certain education, age, income, or ethnic groups.

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