RECENT FINDINGS ON NUTRITIONAL STATUS OF INDUSTRIAL WORKERS

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THE health problems of the population have been discussed by the previous speakers in terms of the incidence and prevalence of disease and impairments. Another phase of health is the sense of well-being, vigor, and vitality which may be materially impaired by subnormal nutrition. Furthermore, malnutrition itself produces pathological changes which, even though they do not progress to the stage of being the direct cause of disabling illness, are a factor in the occurrence of disease. The nutritional status of industrial workers, therefore, is now receiving attention as an important aspect of the health of this group.

Prior to the war there was no organized effort to promote the nutritional status of the industrial worker. Management, and medical departments where they existed, considered the eating habits of the worker and even arrangements for obtaining food to be the personal business of the worker. If special eating facilities had to be provided, concessions for serving food usually were given on a purely commercial basis and there was no supervision of the kinds and quality of food. But manpower requirements for war production focused attention on maintaining the health, efficiency, and morale of the industrial worker and good nutrition was recognized as a primary means to this end. In November 1940, the Food and Nutrition Board of the National Research Council established a Committee on Nutrition of Industrial Workers. This Committee has conducted or sponsored special studies to determine: (a) the quality of diets eaten by industrial workers; (b) the nutritional status of industrial workers; and (c) the improvements and changes needed in feeding facilities to make proper food easily obtainable.

An extensive investigation of the diets and nutritional status of

[1] Milbank Memorial Fund.

about 1,100 aircraft workers at the Lockheed plant in Burbank, California, was conducted from late in November 1941 to March 1942 (1,2). The Study was under the direction of Dr. Henry Borsook with assistance from the Los Angeles County Committee on Nutrition in Industry and the Milbank Memorial Fund. The Lockheed plant had already undergone rapid expansion and approximately 60 per cent (61.6) of the employes in the Study had been employed there less than one year. But only 7.5 per cent had been employed less than three months. The Company had taken no responsibility for the eating facilities, and employes either brought their food with them or purchased it at one of the many food stands which lined the streets near the factory gates. Most of these food vendors sold only such foods as sandwiches, cake, fruit, milk, coffee, and soft drinks. The few restaurants equipped to sell hot meals could serve only a small proportion of the employes. Later, there was some improvement in the availability of hot foods which were brought in paper cartons from kitchens some distance from the plant and sold at the food stands.

The employes in the Study were nearly all young men; 88 per cent were under 35 years of age. All were on the swing shift, that is, they worked from 4 o'clock to midnight. Therefore, their hours for eating were not "normal." Most of the men had a late morning breakfast and a complete hot dinner before going to work at 4 o'clock. Consequently, the swing shift employes were unlikely to begin work on an empty stomach as do many day workers who have little breakfast. Their eating habits were highly variable; some ate very little at the midshift meal period; the majority ate something after work before going to bed and this varied from a light snack to a full dinner; and many ate no breakfast. Thus, the men ate two, three, or four times in twenty-four hours.

The calories estimated for two-day diet histories reported by 250 men averaged about 2,700 calories per day. In every case the employe had been at work on both days. This average is 10 per cent

less than the 3,000 calories per day usually recommended for the average man engaged at moderate activity. Actually, there is, of course, considerable variation among individuals in calorie needs and also the day-to-day consumption of any person will vary. On the basis of age, height and weight, the basal calorie requirements of these men were estimated, but it was not possible to estimate total individual energy expenditures. With even light work, the calorie requirement would be not less than 140 per cent of basal, and the recommended 3,000 calories for men working eight hours at moderate work is about 175 per cent of basal need. Among this group, 39 per cent of the men consumed diets which furnished less than the 140 per cent and only 26 per cent had diets furnishing 180 per cent or more of their estimated basal need.

Obviously, it is not possible on the basis of a two-day diet to select the men who were averaging too low a calorie intake nor to determine exactly how many had insufficient calories. Eighteen per cent of the group weighed 10 per cent or more less than the expected or standard weight for height, and it has been shown (3) that men who are underweight have higher than average mortality rates and also a greater prevalence of some health defects, such as nervousness, frequent colds, and gastric disturbances. Even though they were not losing weight, it seems likely that some of these men would benefit by a greater intake of calories and some increase in weight. The tendency to consume less calories than is deemed desirable has been shown by other studies in which individual consumption records were obtained for employed adult men. There is need of further investigation of optimum caloric intake for industrial workers. Much factory work does not require a great amount of muscular exertion and the standard 3,000 calories may well be too high. On the other hand, an equilibrium may be established between weight and intake at a level which is less than optimum for the individual.

As might be expected, low-calorie diets are frequently associated with the failure to eat a good breakfast. In this group of 250 men,

18 per cent of them had no breakfast on either of the two days, and about 12 per cent had no breakfast on one of the days. Only 36 per cent of the group ate breakfasts which averaged 500 or more calories daily, and 13.6 per cent had 750 or more calories or one-fourth of the daily allowance. Among those with no breakfast or less than 250 calories (88 men), 39 per cent averaged a total daily caloric intake of less than 2,200 calories, and 24 per cent had 3,000 or more calories; but when the breakfast furnished 500 or more calories (91 men), 18 per cent averaged a total caloric intake of less than 2,200 calories and one-half averaged 3,000 or more calories. Other studies have shown that no breakfast or a very light breakfast is a common failing of diets of workers. Turlay (4) found that 11 per cent of 552 West Coast industrial workers ate no breakfast and 53 per cent had breakfasts furnishing less than 300 calories. In a survey of 189 workers in Ithaca, New York, in the summer of 1943, Diehl (5) found that 14 per cent ate no breakfast or only coffee or tea, and the average breakfast furnished about 300 calories or one-tenth of the total daily caloric allowance.

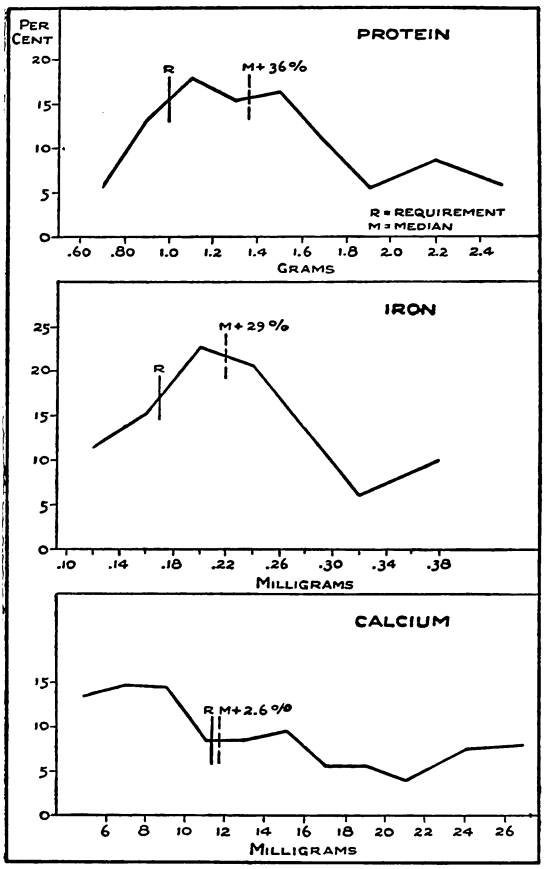

Fig. 1. Percentage distributions of the average daily amount of protein, iron, and calcium per kilogram of body weight in two-day diets reported by 250 Lockheed aircraft workers.

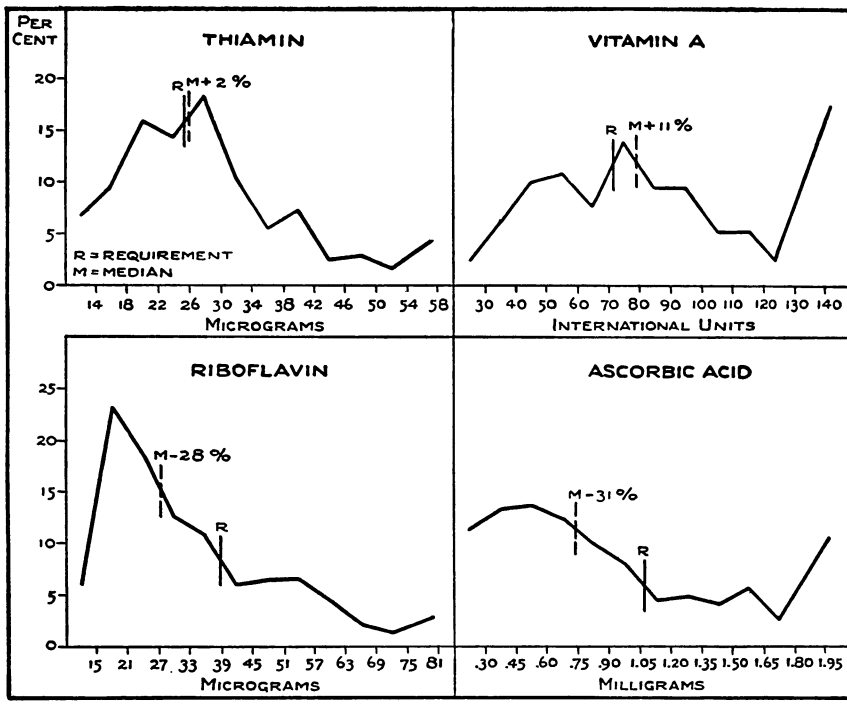

Fig. 2. Percentage distributions of the average daily amount of thiamin, riboflavin, vitamin A, and ascorbic acid per kilogram of body weight in two-day diets reported by 250 Lockheed aircraft workers.

For each of the 250 two-day diet histories, the amounts of protein, iron, calcium, thiamin, riboflavin, ascorbic acid, and vitamin A were estimated. Assay values for vitamin content of cooked foods were used when available; and estimates of losses of thiamin and ascorbic acid were made for other cooked vegetables; and of thiamin and riboflavin in cooked meats. The estimated total daily intake of any nutrient, especially of the vitamins, is only a good approximation, but if most of the diets were of the type to furnish close to the recommended amount of a nutrient, the values would be fairly evenly distributed about a central or mean value nearly equal to the recommended allowance. The percentage distributions of values for individual diets per kilogram of body weight for protein, iron, and calcium are shown in Figure 1; and distributions for vitamin A, thiamin, riboflavin, and ascorbic acid are shown in Figure 2. The

point on each distribution at which the recommended value[2] falls is shown and the median value of the distribution also is indicated.

For protein and iron, the diets are distributed well above the recommended values, and the medians are 36 per cent and 29 per cent, respectively, higher than the requirement. For calcium, the distribution is entirely different. The median value is very slightly above the recommended (2.6 per cent), but the frequency curve does not center around this point. There is a concentration of diets at a level below the calcium allowance and the upper 50 per cent of the diets spread out over a wide range with a considerable proportion at a level double the allowance. In the case of protein and iron, it seems likely that the few low values for the two-day period are accidental and unusual and that few, if any, of the men average a significantly low intake of these nutrients. The frequency of very low calcium values, on the other hand, suggests that diets with low calcium content are not unusual and that a considerable number of these men averaged a low intake not only during the two-day period but also over a longer period.

For ascorbic acid, the distribution curve is somewhat similar in shape to that for calcium, but the median value for ascorbic acid is 33 per cent less than the recommended amount. The greatest frequency for ascorbic acid values is at about one-half the requirement level.

The distribution of diets for vitamin A content is relatively flat and has no definite tendency for the frequency to concentrate near the median which is slightly higher (11 per cent) than the recommended allowance. Values are spread over a wide range, and this reflects the extreme variation in vitamin A values for different foods. From day to day, the dietary level for the same individual can easily shift from one end of the distribution to the other, depending largely on the carotene content of vegetables eaten. A two-day record is

[2] Recommended value per kg. of body weight for each nutrient is the allowance for an adult man recommended by the National Research Council (6) divided by 70, or the weight in kilograms of an average man.

particularly inadequate for judging the dietary intake of vitamin A.

The distribution of dietary values for thiamin tends to center around the requirement level, and the median value is approximately equal to the suggested requirement. There is a considerable range in thiamin values. For riboflavin, the median intake is 28 per cent less than the recommended amount and the maximum concentration of values is at the lowest end of the curve, well below the median value.

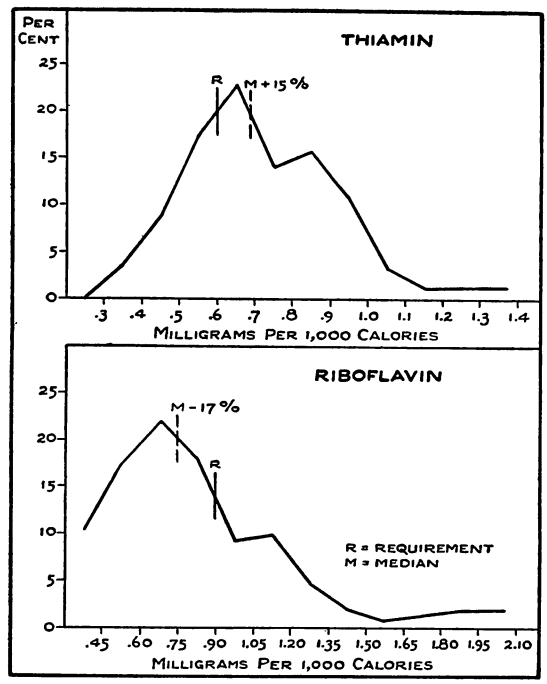

Fig. 3. Percentage distributions of the thiamin and riboflavin per 1,000 calories in two-day diets reported by 250 Lockheed aircraft workers.

The allowances for thiamin and riboflavin are based on a ratio of .6 mg. and .9 mg., respectively, per 1,000 calories. Since the caloric intake for the majority of the men was less than 3,000 calories, the intake of thiamin and riboflavin sometimes equaled the allowance per 1,000 calories although it was less than the suggested total requirement. The distributions of diets according to thiamin and riboflavin values per 1,000 calories are shown in Figure 3. The median intake for thiamin is .69 mg., or 15 per cent above the suggested .60 mg. But for riboflavin, the median value is .75 mg. or 17 per cent less than the allowance of .9 mg. The frequency and degree of deficiencies of both are less in terms of the amount per 1,000 calories than in total amount, but riboflavin is still one of the most frequent deficiencies, second only to ascorbic acid.

In Figure 4, a summary comparison of the different nutrients is shown in terms of the proportions of the diets which furnished less than two-thirds of the recommended allowances. Ascorbic acid and riboflavin values were most frequently low, and 47 and 45 per cent of the diets furnished less than two-thirds of the allowances for these nutrients. Calcium was next with 26 per cent of the diets below the two-thirds level.

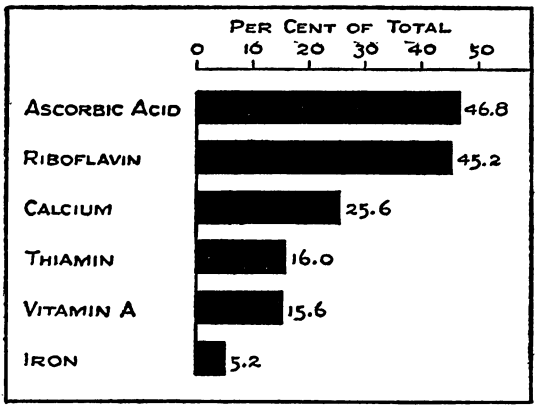

Fig. 4. Percentages of 250 Lockheed aircraft workers who reported two-day diets which furnished less than two-thirds of the recommended allowances per kilogram of weight for six nutrients.

Only 7.6 per cent of these diets met the recommended allowances for both calcium and iron and for the four vitamins. In 71 per cent of the diets, one or more of these six nutrients was less than two-thirds of allowances, and in 42 per cent, two or more nutrients were below this level.

It is obvious that few men were obtaining balanced diets, and the variety of deficiencies and the frequency of multiple deficiencies indicate that this lack of balance in the diets was due to a generally poor choice of foods.

For about 1,100 men, the use of various foods during an entire week was tabulated. Five groups of foods may be considered which are the most important sources of the minerals and vitamins. These are: (1) the green or yellow vegetables; (2) citrus fruits and tomatoes; (3) milk; (4) meat; and (5) eggs. Cereal foods make an important contribution to the minerals and B vitamins, but they are present to some extent in all diets, and enriched bread was in general supply at the time of this Study. For the usual or average American diet, a citrus fruit or tomato, one green or yellow vege-

table, two glasses of milk, a serving of meat, and one egg each day will supply enough of each of the nutrients so that the remainder of the food does not need to be carefully chosen. But the omission of one of these foods, with the exception of eggs, imposes a need for expertly planned substitutes.

In this group of 1,100 employes, only 2.1 per cent or 23 men, reported the consumption during one week of an average daily use of these five types of food equal to or slightly below the standard stated. By food groups, the percentages of the men eating for one week approximately according to the desirable pattern were as follows:

	Per Cent
Green or yellow vegetable, 6 x or more	21
Citrus fruit or tomato, 7 x or more	36
Milk, 10 or more glasses	51
Eggs, 4 or more	59
Lean meat, fish, etc., 5 x or more	95

It is interesting to note the extent of the failure of this group of men to include these essential foods in their diets. One-third of the group had eaten vegetables of any type (excluding potatoes) less than an average of once a day, and one-fourth (24 per cent) of them had eaten green or yellow vegetables less than three times during the week. No citrus fruit in the entire week was reportd by 23 per cent of the men and 17 per cent had had only one or two servings in a week. Nearly one-half of the men had no tomatoes or tomato juice during an entire week. Other fruits were eaten more regularly and 73 per cent of the men had had some kind of fruit at least seven times in the week, but only one-fourth had eaten fruit an average of twice a day as is recommended. Apples and bananas were eaten most often. About 37 per cent of the men reported less than seven glasses of milk during the entire week and 11 per cent had drunk no milk and had had none on cereal.

The infrequent use of citrus fruits and green vegetables accounts

for the low ascorbic acid content of the two-day diets; the low consumption of milk is the primary factor in the low riboflavin and calcium values of the diets.

Comparable data on the eating habits of industrial workers in other parts of the country and of those on the daytime shift are not available. But there is a large amount of evidence from family studies and other surveys to indicate that the dietary pattern of these aircraft workers is in general similar to that of most adults in the United States. Although the choice of foods varies somewhat for different groups, an inadequate consumption of green and yellow vegetables, citrus fruits, and milk is the usual finding. Data from a recent study in Baltimore (7) may be used as one example from the East. From about 950 families, records were obtained on the use of various foods during a one-week period in January or February 1943. In about 60 per cent of these families, one or more persons was employed in a war industry. Proportions of families with low ratings for the use of four types of foods are compared with those for the Lockheed workers in Table 1. The record for the families is somewhat better than that for the Lockheed group, but 42 per cent of these families and 64 per cent of the Lockheed group had a green vegetable less than five times in a week; about one-fourth of the families and one-half of the Lockheed men had citrus fruits or tomatoes less than six times; and one-fourth of the families and one-half of the men had used less than 2.5 quarts of milk per person. It

Table 1. Proportions of Lockheed employes and of Baltimore families for which use of selected foods was unsatisfactory.

Weekly Use of Specified Foods	Lockheed (1,103 Men)	Baltimore (318 Families)[1]
	Per Cent	
Vegetables, Green or Yellow: 4 x or Less	64	42
Citrus Fruit and Tomatoes: 5 x or Less	56	22
Milk (Per Person): 9 Glasses or Less	49	27
Meat: 3 x or Less	2.3	3.8

[1] Wife under 40 years of age.

is very probable, of course, that many men in the Baltimore families had less than a per capita share of the milk, and it is also likely that they did not always eat citrus fruit, which may be purchased especially for the children. But it is apparent that in Baltimore, as well as California, diets frequently failed to include sufficient amounts of milk, citrus fruit, and green vegetables.

The nutritional status of this group of Lockheed employes was investigated by physical examination; examination of the blood for hemoglobin and plasma ascorbic acid; and biomicroscopic examination of the conjunctiva and cornea. The findings have been reported in detail by Borsook, Alpert, and Keighley (2). The results of the examination confirm the dietary evidence and all of the men showed manifestations of one or more deficiencies in some degree. There is time to refer briefly to a few of the findings. Only two men in the group had moderately severe anemia, but 11 per cent had hemoglobin values less than 13.4 grams, which is subnormal by any of the standards. Some degree of conjunctival thickening associated with vitamin A deficiency was found for all, and one-half of the men had elevated areas or "spots" visible by gross examination. Changes in the conjunctiva limited to marked translucency of all four zones of the eyes were found for only 2 per cent of the men. Similarly, every employe examined showed some degree of corneal vascularization, an indication of high prevalence of ariboflavinosis. In 42 per cent of the subjects, long "streamer type" arcades were reported, and in an additional 46 per cent, there were three or more tiers of capillary arcades in the cornea. These conjunctival and corneal conditions may reflect past or long-standing deficiencies of vitamin A and riboflavin, respectively, and once acquired they are not easily removed by diet alone. Thus, the current diet of the men was not necessarily a factor in producing these conditions. Many of the men were consuming a diet currently which would not improve their condition and would, in fact, keep it active. A large proportion of the men complained of eye symp-

toms: 35 per cent had burning, itchy, or gritty feeling in the eyes; 25 per cent complained of eye strain; 43 per cent stated they were uncomfortable in a bright light; and 23 per cent reported that a bright light caused lachrymation.

The examination revealed no cases of acute, severe polyneuropathy, but 25 per cent had one or more signs of degeneration of the nervous system which may indicate thiamin deficiency, although they are not specific.

The plasma ascorbic acid values for these Lockheed employes revealed that plasma values below desirable levels were very common. The precise level at which good ascorbic acid nutrition is maintained is not known, but it is generally admitted that values below 0.60 mg. per cent are not "safe." Plasma values below .60 mg. were found for 52 per cent of the group, and one-third of the men had plasma values below .40 mg. per cent. A low intake of ascorbic acid is reflected promptly in the concentration of ascorbic acid in the blood, and these findings for plasma ascorbic acid are in agreement with the dietary data on the use of citrus fruits and other foods rich in ascorbic acid.

Table 2. The frequency with which citrus fruits or tomatoes were consumed during one week by Lockheed employes who had various plasma ascorbic acid values.

Plasma Ascorbic Acid Mg. Per Cent	Total Number of Men	Per Cent in Each Plasma Group Who Reported Using Citrus Fruits or Tomatoes Specified Times Per Week[1]						
		Total	None	1–2	3–4	5–6	7–8	9+
Total	1,092	100.0	17.5	19.1	18.1	15.8	16.8	12.6
<.20	124	100.0	35.5	29.8	21.0	9.7	4.0	0
.20–.39	241	100.0	25.3	28.6	22.0	12.0	10.4	1.7
.40–.59	216	100.0	24.1	20.8	19.4	16.2	10.6	8.8
.60–.79	193	100.0	10.9	18.1	16.1	19.2	22.8	13.0
.80–.99	148	100.0	5.4	10.1	17.6	20.9	28.4	17.6
1.00+	170	100.0	2.9	4.7	11.8	17.1	25.9	37.6

[1] *See* footnote 3.

It is of interest to compare individual plasma ascorbic acid values with the reported use of citrus fruits and tomatoes for the week preceding the examination. Although the reports on use of these fruits is not quantitative,[3] it is apparent in Table 2 that the relationship is marked. In the group of 124 men with less than .20 mg. ascorbic acid per 100 ml. of plasma, 35 per cent had had no citrus fruits or tomatoes, 30 per cent had had only one or two servings in a week, and only 4 per cent had had seven servings. There is a progressive increase in the use of these foods as plasma ascorbic acid increases. Among the 170 men with plasma values of 1.0 mg. or more, 64 per cent had had seven or more servings of citrus fruits or tomatoes and 8 per cent had had less than three servings. Very few of the men maintained satisfactory plasma ascorbic acid values without the regular use of tomatoes or citrus fruits.

The high prevalence of nutritional deficiencies in this industrial group is in conformity with other evidence that is gradually being accumulated from examinations on various population groups, such as school children, hospital and clinic patients, and family surveys. These data have been compiled and published recently in a Bulletin of the National Research Council (8). It is sufficient here to point out that every survey has disclosed a high prevalence of deficiencies. These are not severe, acute nutritional diseases, but mild, moderate, or, in some cases, severe chronic forms of the deficiencies. The health significance of these deficiency conditions is discussed in the Bulletin (8). Most people are quite unaware of them and there is some tendency to discount their importance. Data on their relationship to disease, lack of vitality, fatigue, nervousness, and various complaints are available from a limited number of studies. Animal experiments, especially the work of Sherman (9), have shown that optimum nutrition increases vitality, fertility, and length of life;

[3] For five days of the week the report was only a statement on the kinds of fruit eaten each day and for the other two days there was a record for each meal. The total in Table 2 is the sum of the number of different citrus fruits or tomatoes mentioned for each day or for each meal, counting tomatoes as one-half a citrus fruit.

and other studies have shown that moderate chronic deficiency over a prolonged period produces unmistakable signs of tissue damage, symptoms of degenerative conditions, and early senility. Studies on humans of the role of malnutrition in disease, ill health, efficiency, work output, etc. are difficult and time-consuming. The need for them is great and undoubtedly their number will increase. Present knowledge, however, affords an adequate basis for acceptance of the premise that a well-nourished employe is a better industrial risk than one in a subnormal nutritional state. The known prevalence of deficiency conditions and the evidence on poor dietary habits give emphasis to the need for an intensified effort to improve the nutritional status of the industrial worker.

In the past two years much has been done to promote public interest in nutrition and to educate the public and home-makers in proper eating. There are national and state agencies and local committees for promotion of nutrition in industry. Dr. Goodhart will tell us about these programs and the progress that is being made.

Among communities and different industrial plants, the problems connected with improving the diets of workers will vary. A properly qualified person should study each situation to determine the special needs and to plan accordingly. Adequate cafeteria service may be available, but the workers may not select good, well-balanced lunches. Such a situation may be due solely to ignorance and food prejudices, but price may be a factor or the appearance or tastiness of some of the more nutritious dishes. Methods of influencing the worker's choice of food must be tried and experience with various methods should be reported for the benefit of others. If in-plant food service is provided, expert planning is required to furnish proper food at low cost and to cook and serve it with a minimum loss of valuable nutrients. Most often, especially in the war plants, food service is totally inadequate. Turlay (4) reported that in seven San Francisco shipyards employing 176,000 workers, less than 9 per cent could obtain any kind of food within the yards. This affects

not only the midshift meal but may eliminate the possibility of obtaining between-meal snacks. The between-meal supplement is recommended as a means of preventing fatigue. In most instances, it should be available within the plant. With imagination and intelligent planning, trained dietitians can devise a variety of highly nutritious supplements for between-meal snacks and as additions to the box lunch.

Box lunches are not necessarily any less nutritious than a hot meal; but as a rule they satisfy hunger but do not supply a fair share of the day's vitamin and mineral needs. The home-packed lunch box is very common. In Baltimore, Miss Downes (7) found that in 884 families with one or more employed persons, 69 per cent of them had one or more members who took lunch from home. In Ithaca, Diehl (5) found that 59 per cent of 189 workers carried lunch from home. But in newly mushroomed war industries, the majority of workers are likely to buy box lunches from vendors. At a San Francisco shipyard, Turlay found that 85 per cent of the employes purchased box lunches. An analysis of 90 box lunches showed that they were "moderately to grossly inadequate since thiamin, vitamin A, riboflavin, calcium, and protein values were low."

Obviously, there is no easy or single method to improve the nutrition of industrial workers. Education of the worker and of the wives is important, but management can play an important role in improving the eating habits of its employes. As it is to the advantage of industry to have well-nourished workers, management should take an active part in working out methods to assure adequate feeding facilities, should supervise the quality of food dispensed, and cooperate in educational programs and other means for influencing the dietary habits of the workers.

A diagnostic service for nutritional deficiencies in industrial medical departments offers a direct, individual approach which holds great potentialities for raising the nutritional status of workers.

Many workers have moderate or well-advanced chronic deficiency conditions which should be corrected. If these conditions are described and interpreted to the employe, and treatment for their correction is undertaken, not only are the more definite nutritional problems cared for but also an interest may be stimulated in diet and maintenance of good nutrition. In addition, knowledge of the prevalence of specific nutritional deficiencies in the group would furnish guidance on the importance of emphasizing special nutrients in in-plant feeding and in the educational program. Furthermore, specific occupational groups could be studied over a period of time for changes in nutritional status. Workers in certain occupations may tend to develop specific deficiencies, and the occupational factors involved and the prevention of such deficiencies should receive special attention.

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