The Nutritional Status of a Puerto Rican Rural Community in Relation to Its Dietary Intake[1]

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THIS report deals with a survey of the nutritional status and dietary intake of a sample population in a rural community of Puerto Rico. Its purpose was twofold: (1) to determine the dietary intake and its adequacy and (2) to study the correlation of said intake with the nutritional status of the individuals as measured by biochemical methods and medical examinations.

The comunity selected for this study was located on a good highway in a formerly prosperous citrus fruit district of the Island, only a few kilometers from a large town. All of its activities centered around one grocery store and one church. Shortly before this study began, the people had participated in a "Land Authority" division of land,[2] therefore some of the houses were still unfinished and many of the small plots of land yet uncultivated. Poultry, pigs, and cows were few. Many of the adults had never attended school, while only a few had succeeded in passing the fourth grade. Most of the school-age children under twelve were attending school part time

A total of 157 individuals, representing 24 families plus a miscellaneous group of 48 persons, 36 of whom were under six years of age, cooperated in all aspects of this study. The sample included 30 percent, approximately, of the entire community.

The survey covered three aspects: (I) a study of the dietary intake, (II) biochemical studies of fasting blood and urine, and (III) medical examinations to determine the nutritional status.

The dietary studies were of necessity made in the home. However, for the medical examinations and collection of blood and urine, four to six subjects were brought each morning to the laboratory before breakfasting and after voiding the morning urine. Upon arrival each individual was given a bottle for collection of the urine in a one-hour sample. Next, 20 cc. of blood were taken from the vein. Height and weight measurements were also taken, after which the subjects were

1. Received for publication August 15, 1946.

2. The Puerto Rico Land Authority is a government corporation that holds as one of its main functions the resettlement of squatters, by allowing them from one fourth to an acre of land for a homesite.

served a good breakfast consisting of orange or grapefruit, egg, bread, butter, "café con leche," and unlimited sugar. The medical examination followed breakfast. Later on, as these individuals were about to return home, each one was given a candy bar.

The breakfast served was undoubtedly better than any these people might have had at home and, together with the pleasant motor trip to a large city, proved to be the incentive responsible for the excellent cooperation received from the group.

As shown in Table 1, the data for all three aspects were obtained on 85 subjects; medical examinations and analyses of urine and blood were made on 24 only, while the medical examinations alone, on 48. This last group of subjects consisted mainly of babies and pre-school children examined in the community by one of the authors.

TABLE 1

Classification of Age-Sex Groups by Data Recorded

Subjects	*Medical Record*	*Medical, Blood, and Excretion Records*	*Medical, Blood, and Excretion Dietary Records*	*Total*
Children				
1–3	25	0	2	27
4–6	11	0	12	23
7–9	5	5	17	27
10–12	5	5	13	23
Girls				
13–15	1	3	6	10
16–20	0	1	5	6
Boys				
13–15	0	0	4	4
16–20	0	1	5	6
Men	0	2	5	7
Women	1	7	16	24
Total	48	24	85	157

Out of the 157 subjects, 100 were children from 1 to 12 years; 14 others were from 13 to 15 years, leaving only 43 adults over 16 years of age.

I. THE DIETARY STUDY

Dietary records were secured by nutritionists who went to the homes of the cooperating subjects and weighed and measured total quantities of the foods utilized in preparing the meals, thus getting accurate data for the recipes used. The weight of the food on each plate, as served to each member of the family, was also recorded, and the uneaten portions were weighed and subtracted from the original

weight, such corrections as were necessary being made then and there.

Although the original plan had been to make a five-day record, the final time spent in this aspect of the work was only two days. It was evident at the start that the diets of these subjects were so monotonous and of such constant quantity and quality that a five-day record would yield but slight differences and would not justify further time being spent on getting additional data. Some of these last were taken in February and others in August, but there was no distinguishing difference between the records for the two seasons.

Meal Patterns

Although a few families had only two meals a day, the majority had three. Coffee was the principal food for breakfast; most of the families served it, since frequently it was the only food. Sometimes it was black but, usually, it was served with some milk. A few families added a cereal such as oatmeal or crackers and, infrequently, bread. Only one family consumed fruit at breakfast.

The noon and evening meals followed one of two patterns. One pattern consisted of a stew made chiefly of root vegetables sometimes seasoned with a little codfish or dry salt beef. The second meal pattern was made up principally of rice and beans, cooked separately, but the beans were invariably seasoned with tomato sauce. Oftentimes, a preparation known as "sofrito," of a tomato sauce base to which onion, garlic, peppers, salt pork, and/or lard were added, was utilized as seasoning. If the family could afford it, a small quantity of meat (ham was always preferred) was chopped into the "sofrito." The rice was usually colored with "achiote." Cook and Axtmayer[3] have shown that this vegetable coloring has a high vitamin A potency. When it is heated in fat, most of the potent constituent is extracted during the first few minutes; repeated extraction by frying draws out the coloring until it no longer affords any vitamin value. However, "achiote" was used in small quantities and so added negligible amounts of vitamin A.

Coffee was served with each meal; some families had it again in the afternoon. When a family had only two meals a day, breakfast was usually omitted, in which case the meals were spaced to late morning and later afternoon. A few families had some accessory

3. D. H. Cook and J. H. Axtmayer, Nutritional studies of foodstuffs used in the Puerto Rican dietary. IV. Extract of the annato seed, *Bixa orellana*; its preparation and physiological properties. Am.J.Trop.Med., 1: 61–75, 1934.

TABLE 2

Average Daily Food Consumption by Age-Sex Groups

Subjects	Milk	Starchy Roots and Fruits	Legumes	Tomato and Citrus Fruits	Vege-tables	Lean Meat	Cereals	Rice	Fat	Sugar
	Oz.	*Oz.*	*Oz.*	*Oz.*	*Oz.*	*Oz.*	*Oz.*	*Oz.*	*Oz.*	*Oz.*
Children	2.5	4.6	0.3	4.4	0.6	0.63	4.1	3.2	0.6	1.0
2–6	2.4	4.6	1.0	2.5	0.7	0.6	3.9	3.7	0.7	0.93
7–9	2.4	7.3	1.2	5.2	1.1	0.8	5.3	4.3	0.7	1.4
10–12										
Girls	3.4	8.8	1.0	4.5	1.5	1.0	6.1	4.8	0.6	1.9
13–15	5.0	14.9	1.6	7.4	0.9	2.3	4.6	3.8	1.1	1.0
16–20										
Boys	3.2	7.6	1.6	12.4	0.8	1.3	6.6	5.3	1.3	2.0
13–15	4.0	10.0	1.2	5.9	0.5	2.3	9.9	9.0	2.3	0.9
16–20	6.4	9.5	2.5	4.1	0.5	2.4	5.7	5.7	0.9	1.4
Men	7.2	8.4	1.4	2.1	1.6	1.5	5.7	3.9	1.0	1.9
Women	4.0	7.4	1.1	4.3	1.0	1.1	5.2	4.3	0.9	1.4
Per Capita										

So few eggs were consumed that they are not included in the above table. The average consumption for the nine subjects, who had any, was 17 (g.) each.

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Children	2.5	4.6	0.3	4.4	0.6	0.63	4.1	3.2	0.6	1.0
2–6	2.4	4.6	1.0	2.5	0.7	0.6	3.9	3.7	0.7	0.93
7–9	2.4	7.3	1.2	5.2	1.1	0.8	5.3	4.3	0.7	1.4
10–12										
Girls	3.4	8.8	1.0	4.5	1.5	1.0	6.1	4.8	0.6	1.9
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16–20	6.4	9.5	2.5	4.1	0.5	2.4	5.7	5.7	0.9	1.4
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food in the afternoons, such as soft drinks or a bit of cane; occasionally, coffee was served before retiring.

The findings from the dietary records will be presented in two parts: food consumption records in terms of basic foods used, and adequacy of the diets as expressed in quantities of the nutritive constituents.

Food consumption. Table 2 shows the average quantities of the basic foods consumed by the different age-sex groups.

Milk. Milk consumption was conspicuously low, the per capita intake for the group as a whole being only 0.5 cup, or about 4 ounces. Contrary to usual findings, the intake was lowest for young children, amounting to 0.25 cup, or 2.5 ounces only, for children up to 12 years. The amount gradually increased up to nearly 0.75 cup, or 6 ounces, for men; to almost a cup, or 7.2 ounces, for women. This situation can be explained by the fact that milk was used largely in "café con leche" and, since the adult population drank more coffee, they also consumed more milk.

Nutritionists consider milk as the foundation of a good diet because of the many nutritive constituents that it supplies. Even the minimum low-cost diets set up by the Bureau of Human Nutrition and Home Economics[4] allow a daily intake of 3 to 4 cups, or 24 to 32 ounces of milk, for children, and 2 cups for adults. One pint of milk is, moreover, commonly regarded as the bare minimum a child should have, yet the children of this study received only about one eighth of even this minimal standard.

Averages, of course, do not reveal the exact picture. Although the average consumption was 4 ounces, 16 percent of the subjects drank no milk at all, and another 31 percent consumed less than 2 ounces. Only 13 percent of the group drank more than 8 ounces.

Starchy roots and fruits. The bulk of the diet was make up of starchy roots and vegetables, consisting of tubers of all kinds: *yautía, ñame, yuca, malanga,* breadfruit, plantain, and green banana. Average consumption of these foodstuffs for the various age-sex groups ranged from 4.6 for the pre-school age to 14.9 ounces for the older girls, with a per capita average of 7.4 ounces that was 1.4 to 3 times more than the quantity recommended in the low-cost market lists. Only small quantities of yellow tubers found a place in the dietary. Most of the starchy roots were white, thus failing to provide vitamin A at essential levels. The individual consumption levels of this group

4. Bureau of Home Economics, Three market lists for low-cost meals. U. S. Department of Agriculture, Washington, D. C., 1942.

of foods ran from 0 to 23 ounces; 18 percent consumed less than 2 ounces, while 6 percent had more than 16 ounces.

Vitamin C-rich foods. These foods were limited to tomato and grapefruit; the data on tomato includes both the sauce and the fresh variety. Most families used tomato sauce for the seasoning of vegetable stews and beans; generally, a four-ounce can was added to the stew or the beans regardless of the quantities of other foods in the receipt. However, any vitamin C that the sauce contained was reduced by the long cooking that was customary. Fresh tomatoes were utilized in small quantities; occasionally, one or two small ones were sliced into the stew or soup, but they were almost never served raw.

Individual consumption of this basic food group ranged from none to 30.5 ounces. Although 70 percent of the subjects ate no grapefruit, the average consumption of foods providing vitamin C was 4.4 ounces. This average is misleading as to individual consumption, since 10 percent of the subjects never consumed either tomato or grapefruit; 34 percent consumed less than one third of an ounce; and another 8 percent, more than a third but less than one ounce of the foods in this group. It takes 3.5 ounces to provide adequate amounts of vitamin C, when no other vitamin C-rich foods are included in the diet.

Dried beans, peas, and nuts. These people like beans and, if possible, eat them once or twice daily. In the present study, average consumption ranged from 0.3 ounce for the pre-school age to 2.5 ounces for men, with a per capita average of 1.1 ounce. Thirteen percent of the subjects consumed less than half an ounce, while 9 percent had between 3 and 4 ounces. Red kidney beans were the favorite kind, as shown by the fact that 90 percent of all the beans used by some families were of this variety. There were no soybeans in the dietary.

Vegetables other than starchy roots. For dietary purposes, succulent vegetables are usually divided into two classes: (a) leafy, green, and yellow, and (b) all others. Vegetables have not been so divided in this study, because the quantity of neither group was sufficiently large for such a division to have any meaning. Average consumption of all vegetables ranged from 0.5 for the pre-school group to 1.6 for the women, with a per capita average of one ounce. The list included pumpkin, peppers, corn, cabbage, eggplant, onion, avocado, okra, pimento, peas, ripe banana, olives, capers, and garlic. Fifty seven percent of the subjects consumed no vegetables at all, while another 19 percent consumed less than 5 g. (0.11 ounces).

Eggs. As the average consumption of eggs was so low that it approached zero, Table 2 does not contain a column for eggs. Only 9

TABLE 3

Comparison of Food Consumption per Capita with Other Studies of the Caribbean Area

Kind of Food	*Puerto Rico*		*Barbados*	*Jamaica*	*Trinidad*	*Bureau of Human Nutrition & Home Economics Low-cost Market Lists*
	Present Study	*Descartes et al.*				
	Oz.	*Oz.*	*Oz.*	*Oz.*	*Oz.*	*Oz.*
Milk	4.0	3.6	2.9	1.8	1.3	23.2
Starchy roots	7.4	20.0	19.2	35.2	12.4	4.2
Tomato; citrus fruits	4.3	0.7	0.5	4.4	3.4	3.5
Other vegetables and fruits	1.0	0.87	0.5	4.4	3.4	12.5
Dried beans, peas, and nuts	1.1	1.9	0.25	0.8	0.6	0.75
Meat	1.1	1.53	1.9	1.3	2.6	2.8
Eggs	0.06	0.2	1.9			0.58
Flour, bread, and cereals	5.2	8.2	3.9	8.3	12.4	6.3
Rice	4.3	7.0	2.4	0.3	2.7	
Fats	0.9	2.0	0.8	0.6	1.4	1.7
Sugar	1.4	1.4	3.6	1.9	3.2	1.7

of Eleven Nutrients,[9] from Asenjo's,[10] Axtmayer and Cook's[11] analyses, and from unpublished material of the School of Tropical Medicine, is presented in Table 4.

TABLE 4

Intake of Dietary Essentials by Age-Sex Groups

Dietary Essential	*Pre-School*	*School Age*	*Men*	*Women*	*Per Capita*	*Per Man Equivalent*
Calories	1,129	1,435	2,061	1,816	1,432	1,570
Protein (g.)	26.8	33.1	54.3	46.1	36.6	38.8
Calcium (mg.)	0.21	0.21	0.35	0.38	0.27	0.21
Iron (mg.)	6.9	8.7	14.0	10.4	8.4	8.7
Vitamin A (I. U.)	972	1,054	1,308	1,434	1,163	1,364
Thiamine (mg.)	0.47	0.56	0.82	0.67	0.6	0.64
Riboflavin (mg.)	0.47	0.49	0.84	0.82	0.59	0.58
Niacin (mg.)	4.6	5.2	7.6	6.7	5.8	6.1
Ascorbic acid (mg.)	51	60	75	53	51	55

The column headed "per man-equivalent" is a weighted column in which the total figure for each nutrient has been divided by the "man-equivalent" for each age-sex group, in accordance with the National Research Council's recommended allowances using a sedentary man as the unit. For example, the recommended allowance of riboflavin for a sedentary man is 1.6 mg., but it is 0.9 mg. for a three-year-old. The three-year-old's allowance is 56 percent that of the man and is therefore the equivalent of 0.56 of the man's. If there are four children in the group, the man-equivalent would be 2.24 for the group. So, finding the total man-equivalents for the population and dividing them into the total intake of riboflavin for the whole population will give the riboflavin per man-equivalent. When only one unit is used to describe the adequacy of a miscellaneous group against a standard, the per man-equivalent will be a more accurate figure than a per capita figure, which does not take into account the varied needs of the individual members of the population.

Because Puerto Ricans are of low stature and slight weight, it was argued that the National Research Council's Recommended Allowances were more liberal than necessary for Puerto Ricans. For that reason, these allowances were revised, utilizing the average Puerto Rican weight for each age-sex group. Certain criticisms of the validity of the height-weight tables used will be pointed out later; they

9. Bureau of Human Nutrition and Home Economics in cooperation with National Research Council, Tables of Food Composition. Pub. No. 572, U. S. Department of Agriculture, 1945.
10. C. F. Asenjo, Riboflavin content of tropical foods. Food Research, 11: 137-141, 1946.
11. J. H. Axtmayer and D. H. Cook, Manual de Bromatología (Washington, D. C.: Oficina Sanitaria Panamericana, 1942).

TABLE 5

Recommended Allowances Revised for Puerto Ricans, Based on Salivia's[a] Height-Weight Tables and National Research Council Recommended Allowances

Subjects	Weight	Calories	Protein	Calcium	Iron	Vitamin A	Thiamine	Riboflavin	Niacin	Vitamin C
Infants–Children	*Kg.*		*G.*	*G.*	*Mg.*	*I. U.*	*Mg.*	*Mg.*	*Mg.*	*Mg.*
1–3	11	1000	34	0.9	6	1300	0.6	0.8	5	30
4–6	18	1500	47	0.9	8	2300	0.8	1.1	7	50
7–9	24	1900	58	0.9	9	3300	1.0	1.4	9	60
10–12	30	2200	63	1.0	10	4000	1.1	1.6	10	65
Girls										
13–15	42	2300	67	1.1	13	4500	1.2	1.7	11	70
16–20	48.5	2100	66	0.9	13	4500	1.1	1.6	10	70
Boys										
13–15	39	2700	71	1.2	13	4500	1.4	1.7	13	80
16–20	56	3300	90	1.2	13	5200	1.7	2.2	16	90
Men										
Sedentary	56	2100	60	0.7	10	4500	1.1	1.5	11	70
Moderately active		2500					1.4	1.6	12	70
Very active		3600					1.8	2.0	16	70
Women										
Sedentary	50	1900	50	0.7	10	4500	1.0	1.3	10	65
Moderately active		2200					1.1	1.5	11	65
Very active		2700					1.4	1.6	13	65
Pregnant										
Lactating										

[a] L. A. Salivia, Bul. University of Puerto Rico, December, 1934.

were, however, the most reliable available at the time. Table 5 contains these revised allowances.

The age groups in Table 5 are different from the ones described in the National Research Council's Tables of Recommended Allowances. Therefore, in order to be able to compare the intake of these groups with the recommended allowances, the National Research Council figures had to be recalculated on a weighted scale, depending upon the number of individuals in each smaller class of the larger group. After the allowances were revised for Puerto Ricans, they were also regrouped, by the National Research Council method, into larger groups of pre-school and school-age children, men, and women. Obviously, these weighted figures are applicable to the present survey only and cannot be applied to any other area or group. Table 6 gives the allowances thus arrived at for these groups and is presented merely because it is the basic table from which the percentages found in Table 7 have been derived.

The adequacy of the dietary intake, as measured by the two tables of recommended allowances, is shown in Table 7.

These data are presented graphically in Chart 1. The solid bar represents the level, if measured against the National Research Council's recommended allowances. The extended clear portion of the bar shows how much closer the intake meets the revised allowances for Puerto Ricans.

Tables 4, 7, and 8 present the actual intake, how it measures up against the recommended allowances, and the percentage of individuals that meet the various fractions of the allowances, respectively. Charts 1 and 2 present in graph form the material found in Tables 7 and 8, respectively. These tables are not discussed separately, but reference is made to each as the different dietary essentials are taken up.

Because nutritionists commonly add, as matter of safety, 50 percent of the basal need of a dietary constituent to the basal need, and because the National Research Council's recommended allowances are not considered minimal, two thirds of that standard will be used in this discussion as the minimal amount that can possibly provide adequate nutrition. Here, then, the term "minimal adequate intake or level" is defined as 70 percent, or more, of the National Research Council's recommended allowances. Since the difference between the National Research Council's figures and those revised for Puerto Rico is not great, and since the former are used as a yardstick for most dietary surveys, they will be used as the reference standard in any further discussions.

TABLE 6

Recommended Allowances as Weighted for the Subjects of This Study

Dietary Essential	Pre-school	School Age	Men	Women
Calories				
N. R. C.	1,543	2,376	3,150	2,171
P. R.	1,429	2,139	2,700	1,947
Protein (g.)				
N. R. C.	49	69	85	64
P. R.	45	62	75	54
Calcium (mg.)				
N. R. C.	1.0	1.1	1.1	0.85
P. R.	0.9	1.0	0.9	0.7
Iron (mg.)				
N. R. C.	8	12	14	13
P. R.	7.7	10.3	11.5	10.7
Vitamin (I. U.)				
N. R. C.	2,428	4,207	5,500	5,000
R. R.	2,486	3,829	4,850	4,500
Thiamine (mg.)				
N. R. C.	0.8	1.2	1.5	1.1
P. R.	0.7	1.1	1.5	1.0
Riboflavin (mg.)				
N. R. C.	1.2	1.7	2.0	1.6
P. R.	1.1	1.5	1.9	1.4
Niacin (mg.)				
N. R. C.	8	12	15	11
P. R.	7	10.0	14	10
Ascorbic acid (mg.)				
N. R. C.	48	71	88	72
P. R.	47	66	67	66

TABLE 7

Average Intake of Dietary Essentials Expressed as Percentage of Recommended Allowances

Dietary Essential	Pre-school		School Age		Men		Women	
	N. R. C.	P. R.	N. R. C.	P. R.	N. R. C.	P. R.	N. R. C.	P. R.
Calories	74	79	60	67	67	76	87	93
Protein	55	60	49	53	66	72	73	85
Calcium	21	23	19	21	35	39	45	54
Iron	88	90	74	84	104	122	79	97
Vitamin A	40	39	26	27	24	27	30	32
Thiamine	81	67	47	51	57	59	47	67
Riboflavin	41	43	29	33	47	44	54	59
Niacin	60	66	45	52	50	54	59	67
Ascorbic acid	104	108	83	92	86	112	73	80

TABLE 8

Percentage of Population Meeting Different Fractions of the Recommended Allowances

Dietary Essential	Fraction of Recommended Allowances											
	1 to 24 Percent		25 to 49 Percent		50 to 69 Percent		70 to 99 Percent		Over 100 Percent	
	N. R. C.	P. R.	N. R. C.	P. R.	N. R. C.	P. R.	N. R. C.	P. R.	N. R. C.	P. R.
Calories	2	1	17	13	40	34	28	31	12	18
Protein	1	1	41	34	37	43	14	16	7	13
Calcium	59	54	26	27	9	6	4	11	1	2
Iron	2	1	8	5	35	23	35	34	20	36
Vitamin A	42	42	35	36	19	14	5	5	0	1
Thiamine	1	1	52	25	29	39	14	21	3	14
Riboflavin	29	25	49	44	10	20	9	8	2	4
Niacin	8	5	45	12	24	39	17	23	5	21
Ascorbic acid	15	14	22	20	21	14	15	22	26	28

Calories. Although the caloric intake for all groups failed to meet the full recommended allowances, the averages—except in the case of school children—were equal to, or better than, the minimum recommended. Nevertheless, the average per man-equivalent was only about 1,600 calories instead of the 2,500 that is recommended for sedentary men. School-age children also got only 60 percent of their recommended allowance. Although three of the four groups received the minimal allowance, still 48 percent failed to reach that level (see Table 8), even when the Puerto Rican standard was utilized.

Oftentimes the caloric need is expressed as calories per kilogram of body weight. By such estimates, based on actual body weight of the individual, the pre-school children and the men were 20 percent short of their need; the school children were 26 percent and the women, 16 percent below their need. Although there were somewhat more calories from carbohydrate because of the low consumption of fats, the usual distribution of calories from carbohydrate, protein, and fat were reasonably close to good practice.

Protein. The average protein content of these diets was 49 to 73 percent of the National Research Council's recommendations, or 60 to 86 percent of the Puerto Rican recommendations. Even by the last more liberal estimate of adequacy, consumption of protein was low. The total population averaged approximately 58 percent of the recommended allowance. When the protein was calculated as grams per man-equivalent, it was found to be 39 g. Table 8 shows that 79 percent failed to meet the minimal allowance, and that 42 percent had less than half the recommended allowance.

If all the protein in the diets had been "adequate protein" (of animal origin), the situation would not have been quite so serious. However, only 27 to 44 percent of it was of high biologic value. The National Research Council recommends that one third to one half of the protein utilized be of animal origin. Though the percentage in these diets was approximately that, the latter were low in total protein and, consequently, low also in animal protein. Reference to Table 1 shows that the intakes of meat, milk, and eggs were poor. It has been shown that the protein of rice—though small in amount—is a plant protein of good biologic value and may add some of the amino acids that are so essential. However, the beans in these diets furnished a protein of poor biologic value, thus reducing the quality of the total protein.

Calcium. The calcium deficiency was the most serious of all the dietary deficiencies; the intake was extremely low in all the groups averaging as little as 0.2 g. for the children and increasing to only 0.38 g. for the women. These figures were only 21 to 45 percent of the recommended allowance. Fifty-nine percent of the individual intakes was less than one fourth of the National Research Council's recommendation; only 4 percent of the subjects had as much as the minimum suggested above. One percent, however, had the full allowance.

This low calcium intake was related directly to the low milk consumption. When children receive less than 2.5 ounces of milk, adequate amounts of calcium cannot be obtained from the calcium-poor food that makes up the rest of the diet. The milk furnished only 0.085 g. of calcium, which was only 4 percent of the 0.21 g. average for children. Had each child received a pint of milk, at least, his calcium intake would have risen to 0.66 g., but this amount would still have been 34 percent short of the recommended allowance.

Even though probably less than 3 percent of the child population showed signs of rickets, the small stature of the people, the high incidence of dental caries and dentures, and other clinical manifestations caused by calcium deficiency pointed definitely to an insufficient dietary calcium.

Iron. With the exception of one group who actually had the recommended amount of iron, the intake of iron was fair, even though the per man-equivalent was only 9 mg. instead of the recommended 12. The average for all four groups was 81 percent of the allowance, thus exceeding the basic minimum. However, 45 percent had less than the minimum; 10 percent had less than half the full allowance, while 20 percent actually exceeded the allowance.

Vitamin A. The vitamin A content of the diets was extremely low. Averages ranged from 24 percent of the recommended allowance for men to 40 percent for children; consumption per man-equivalent was 1,364 I. U. as against 5,000 recommended by the National Research Council. Ninety-five percent of the subjects had less than the minimal requirement, while 77 percent had less than one half of the full allowance, and 42 percent less than one fourth that amount. The utilization of no butter, little milk, and hardly any yellow or green vegetables accounted for the low intake. Not only was the quantity of vitamin A low, but it was also primarily derived from plant sources.

The National Research Council points out that, when vitamin A is of plant origin, twice as much will be needed to make up the recommended allowance. The allowance of 5,000 I. U. for men is based on the assumption that two thirds of it will be from plant origin. In

the diets under study, almost all of it came from plants, thus diminishing its protective value.

A theoretical diet containing average amounts of all the foods consumed by all the women has been evaluated for vitamin A. It contained 2,069 I. U. Now, if all the starchy roots had been yellow sweet potato, and if all the other vegetables had been greens, the vitamin A value of the diet would have risen to 11,865 I. U. If the root vegetables alone had been yellow sweet potato, the vitamin A value would have risen to 6,000 I. U.

Thiamine. Eighty-two percent of the subjects had less than the minimal allowance of thiamine, while 77 percent had less than one half, and 42 percent less than one fourth, of the amount recommended by the National Research Council. Averages ranged from 47 percent of the allowance for school-age children to 81 percent for the pre-school age. The per man-equivalent intake was 0.64 mg. as against the recommended 1.6 mg.

Another method of estimating the adequacy of dietary thiamine is to calculate the milligrams per kilogram of body weight and the milligrams per 1,000 calories. If a subject is underweight, the thiamine-kilogram ratio may be good, even though the dietary thiamine is obviously low and the subject obviously in poor nutritive condition. Similarly, if the caloric intake is very low, a satisfactory ratio may be obtained even though it is evident that the subject is poorly nourished. Therefore, these ratios must be interpreted in the light of the nutritional condition of the subject and the caloric level of the diets. When the subject is underweight and the ratio small, then it furnishes strong evidence of the inadequacy of the thiamine intake.

Table 9 shows that all the ratios of thiamine to body weight were lower than the ratios established by the National Research Council's recommended allowances. This is interpreted to mean that there was not enough thiamine to nourish the tissues even of underwieght bodies. That some of the thiamine-calorie ratios were good is not necessarily indicative of good nutrition, for the caloric value of most of the diets was low. It means that, if the caloric value of the diets had been high enough and had maintained the same ratio, the diets would have contained sufficient thiamine. Two groups had low thiamine-calorie ratios; in these two groups it means that even if the caloric value of the diet were increased with the same quality of food, the thiamine content would still be low.

Riboflavin. Riboflavin was the third conspicuously low component in these diets. Eighty-eight percent of the subjects took less than the minimal requirement, while 78 percent had less than one half, and

TABLE 9

Thiamine Kilogram of Body Weight and per 1,000 Calories

Source of Data	*Pre-school*	*School Age*	*Men*	*Women*
		Thiamine per Kilogram		
Present study	0.032	0.022	0.014	0.014
N. R. C.	0.043	0.029	0.022	0.020
Percentage of N. R. C. ratio	74	76	64	70
		Thiamine per 1,000 Calories		
Present study	0.49	0.40	0.46	0.38
N. R. C.	0.5	0.5	0.48	0.5
Percentage of N. R. C. ratio	100	80	96	76

29 percent less than one fourth of the National Research Council's recommended allowance. The averages for the different groups ranged from 29 percent of the National Research Council allowance for school children to only 54 percent for women. Although the intake of riboflavin for women was far from satisfactory, it reached the high level found because of the consumption of more milk in coffee than the other groups.

There has been some recent evidence that protein and riboflavin metabolism are related. Table 10 shows the dietary relationship expressed as a ratio of milligrams of riboflavin to grams of protein and compares the former with a similar ratio found in the National Research Council's allowances.

TABLE 10

Riboflavin per Gram of Dietary Protein

Source of Data	*Pre-school*	*School Age*	*Men*	*Women*
Present study	0.0185	0.0143	0.0150	0.0167
N. R. C.	0.0236	0.0215	0.0293	0.0281
Percentage of N. R. C. ratio	78	67	51	60

Of course, if the protein of the diet is low, the proportion of riboflavin to protein may appear satisfactory even though the riboflavin may be also low. It has been established that the protein of these diets was low; therefore, since the riboflavin-protein ratios were only

51 to 78 percent of those in the recommended allowances, this could only mean that the riboflavin content of the diet should be increased by the addition of riboflavin-rich foods, such as milk, rather than by increasing the quantity of the foods already present in the diets.

Niacin. Niacin averaged 45 percent of the National Research Council's allowance for school-age children to 60 percent for the pre-school age. The per man-equivalent was 6.1 mg. as against the recommended 12. However, 77 percent of the subjects failed to get the minimal amount needed, while 53 percent had less than one half of the whole recommended allowance.

Tepley, Krehl, and Elvehjem[12] reported that 100 g. of coffee contain from 8 to 10.9 mg. of niacin, or that one cup contains 0.78 to 1.28 mg. As it was impossible to detect niacin in the coffee by the analytical method used in this laboratory, niacin from coffee has not been included in these calculations. However, when Tepley *et al.'s* figure for coffee was applied to the present diets, 68 percent of the subjects still failed to meet the minimal allowance for this vitamin.

Ascorbic acid. The average for ascorbic acid was good. No group was found below the minimal requirement, the range being from 73 to 116 percent of the recommendation. However, when individual consumption levels were studied, it was evident that a high percentage of the subjects had little ascorbic acid in their diets and that the average figure was deceiving because of the excessive intake of a few subjects. Fifty-eight percent had less than the minimal requirement and 37 percent less than one half of the recommendation.

In recapitulation, it is apparent from Chart 1 that, by either standard, the dietary constituents were all low, except in the cases of iron for men and vitamin C for the pre-school child. Calcium, vitamin A, and riboflavin were conspicuously low, amounting to less than 50 percent of the allowances. Some groups amounted to only about 25 percent of the latter. When the Puerto Rican standard was utilized, the picture was slightly better, though the dietary intake still did not measure up to the allowances. When the individual intake of nutrients was considered, as shown in Chart 2, the deficiencies were even more apparent; 59 percent of the people had less than one fourth, and 85 percent had less than one half of the recommended calcium. The extent of the deficiencies in vitamin A was almost as serious, for 42 percent of the people had less than one fourth of the allowance, and 78 percent had less than one half. A similar condition

12. H. T. Tepley, W. A. Krehl, and C. A. Elvehjem, Studies on the nicotinic acid content of coffee. Arch.Biochem., 6:139, 1945.

was observed for riboflavin; 29 percent had less than one fourth, and 78 percent less than half, of the recommendations.

II. BIOCHEMICAL STUDIES

Fasting blood plasma was analyzed for vitamin A and carotene by the method of Carr-Price,[13] vitamin C, of Farmer and Abt,[14] and protein, by that of Kjeldal,[15] as adapted by Hawk and Bergeim. Whole blood was studied for hemoglobin by the Sahli method; red blood cells were counted. The one-hour fasting urines were analyzed for riboflavin by the micro-biological method of Snell and Strong,[16] thiamine by the thiochrome method of Hennesey and Cerecedo,[17] and the F_2 factor (N-methyl-nicotinamide) by the Huff and Perlzweigh method.[18]

As previously explained, the blood and urine samples were not collected on the same day in which the dietary record was taken. However, the diets were so monotonous and so standardized that it was thought that the blood and urine analyses would be reasonably constant from day to day.

Blood Studies

Table 11 shows the average values for the different blood constituents and the percentage of subjects who had lower than normal values for each one.

Hemoglobin. The hemoglobin concentration of the bloods failed to reach the normal value of 14.5 percent (14.5 = 100 percent) in 89 percent of the cases; 32 percent were below 12 g. percent, and 6 percent, below 10 g. percent.

Correlation of hemoglobin concentration with the iron intake of 80 subjects showed that 58 percent had better than the minimal allowance of iron (70 percent of the National Research Council's recommended allowance). Of this 58 percent, two thirds had a

13. J. C. Abels, A. T. Gorham, G. T. Pack, and C. P. Rhoades, Metabolic studies in patients with cancer of the gastrointestinal tract. Plasma vitamin A levels in patients with malignant neoplastic disease, particularly of the gastrointestinal tract. J.Clin.Investigation., 20: 749–764, 1941.

14. C. J. Farmer and A. F. Abt, Ascorbic acid content of blood. Proc.Soc.Exper.Biol.and Med., 32: 1625–1629, 1935.

15. P. B. Hawk and O. Bergeim, Practical Physiological Chemistry, 11th ed. (Philadelphia: P. Blakiston's Son and Co., Inc., 1937).

16. E. E. Snell and F. M. Strong, A microbiological assay for riboflavin. Ind.and Eng. Chem., Anal.Ed., 11: 346, 1939.

17. D. H. Hennesey and L. R. Cerecedo, Thiocrome method for thiamine. Mimeographed material from Merck and Company.

18. J. W. Huff and W. H. Perlzweigh, N'-methyl-nicotamide, metabolite of nicotinic acid in urine. J.Biol.Chem., 150: 395–400, 1943.

TABLE 11

Average Concentration of Components in Fasting Blood

Components	*Pre-school Children*	*School Age Children*	*Men*	*Women*	*Average*	*Accepted Normal Values*	*Percentage Below Normal*
Hemoglobin G. percent (14.5 g. = 100 percent)	11.6	12.7	12.9	13.0	12.7	12.0	31
Red blood cells[a] (Millions)	4.3	4.2	4.3	4.1	4.2		64
Plasma protein (G. percent)	6.3	6.6	6.4	6.8	6.6	6.2–8.0	23
Vitamin A (Mcg. percent)	13.3	17.0	25.3	13.4	16.8	30–70	83
Carotene (Mcg. percent)	51.4	47.8	55.0	67.3	54.5	100–300	84
Ascorbic acid (Mg. percent)	0.5	0.7	0.54	0.4	0.6	0.6–2.0	58

[a]Wintrobe's range for red cells:
4.5–4.6 4.7–4.8 5.4 4.8

hemoglobin concentration of better than 12 g. percent. Of the remaining 42 percent with less than a minimal allowance of iron, about one third had less than 12 g. percent of hemoglobin. In general, when hemoglobin concentrations were arranged in ascending order, the dietary levels also ascended. There was not, however, perfect correlation, for the adequate iron intake did not always accompany good hemoglobin values, nor did a low iron intake always accompany low hemoglobin levels.

Red blood cells. Since normal red cell counts vary with age and sex, each group had to be considered separately. Table 11 shows that no group measured up to Wintrobe's normal values, for 64 percent of the subjects had fewer than 4,500,000 red blood cells while 32 percent had fewer than 4,000,000. Of the 80 subjects who had both dietary records and R. B. C. counts, 57 percent had as much as the minimal allowance of dietary iron; between one fifth and a fourth of that number had more than 4,500,000 R. B. C. About three fourths of those who had inadequate iron also had low red cell counts. In general, the red cells increased as the dietary iron increased, although in only 41 percent of the cases with as much as the minimal iron allowance was it accompanied by normal red cell counts.

Color index indicates the type of anemia. Although 89 percent of this group had less than normal hemoglobin concentration, 46 percent showed a normochromic blood picture, while 41 percent definitely were hypochromic and 11 percent only slightly hypochromic. Of the group whose hemoglobin concentration was less than 12 g. percent, only 30 percent had a normochromic blood picture, while 56 percent were hypochromic. Hookworm was found about as frequently in one group as in another. It is apparent from these figures that a slight anemia dominated the blood picture and that a marked hypochromic blood picture was found in about half the group.

Plasma protein (normal range: 6.2-8.0 g. percent). Analyses of 94 blood plasmas showed that 23 percent of them contained less than 6.2 g. percent. It was somewhat surprising that the plasma protein gave such a good average, since the dietary protein of 80 percent of the subjects was below the recommended minimal allowance. It was not surprising, however, that 22 percent of those with low intake also had low plasma protein levels. The relatively large quantity of rice in the diet was suggested as a contributing factor to the good plasma protein levels; even though the protein content of rice is low, it is of a good quality. Kempner[19] used a rice-fruit juice diet in the treatment of hypertension and was able to maintain satisfactory plasma protein levels with no other dietary protein.

Vitamin A and carotene (normal range: 30.0-70.0 mcg. percent for vitamin A, and 100 to 300 mcg. percent for carotene). Eighty-three percent of the bloods had less than 30 mcg. percent of vitamin A; the average for the entire group was only 16.8 mcg. percent. Only one percent of the group took as much as the recommended minimal allowance of vitamin A. That even as many as 17 percent had satisfactory plasma protein may be explained by the fact that vitamin A can be stored in the tissues, and satisfactory blood values can be maintained long after the dietary levels are greatly reduced. Sherman[20] points out that "it is well to keep in mind that the body does not quickly acquire nor quickly lose the full store of vitamin A which it is capable of taking on when habitually given liberal intake."

Carotene concentrations were as unsatisfactory as those of vitamin A, for 92 percent of them were below the normal range, and the average was only 55.0 mcg. percent. This reflected the long practice of using white instead of yellow roots and of eating little of other yellow or green vegetables or fruits.

Ascorbic acid (normal range: 0.6-2.0 mg. percent). In 58 percent of the cases, ascorbic acid concentration of the plasma was below 0.6 mg. percent, while 38 percent were under 0.5 mg. percent, and 13 percent below 0.3 mg. percent. These figures agree with the results

19. W. Kempner, Compensation of renal metabolic dysfunction. Treatment of kidney disease and hypertensive vascular disease with rice diet. North Carolina Med.J., 6:61–87; 117–161, 1945.

20. H. C. Sherman, Nutrition and Food Chemistry, 7th. ed. (New York: The Macmillan Company, 1946).

of Munsell, Cuadros, and Suárez[21] who found 58 percent of their healthy subjects with plasma ascorbic acid concentration values in the deficiency range. The average concentration for the group was 0.59 percent, just reaching the lowest figure for the normal range. It was anticipated that plasma concentrations would be low for 58 percent of the subjects took less than the minimal allowance of ascorbic acid in their diets. This was generally true, for 61 percent (about two thirds) of those whose plasma concentrations were less than 0.6 mg. percent took less than the minimal allowance. If there were good correlation between the intake and p'asma concentration, it would be expected that all plasma concentrations would be less than 0.6 mg. percent when the intake was below the minimal allowance. However, such was not the case. Only 60 percent of that group had less than 0.6 mg. percent of ascorbic acid in the plasma. On the other hand, 56 percent of those with satisfactory concentrations had a low intake of ascorbic acid. Although there was not good agreement between individual intake and the concentration in the plasma, very good agreement was observed between the two when only the averages were considered. This agreement can be used to advantage when large-scale planning for improving the nutrition of groups is undertaken.

Urinary Excretions

The excretion of the water-soluble vitamins in urine has been used by many investigators as a means of measuring the adequacy of the dietary levels of these vitamins. Some measure the saturation of the tissues by utilizing a 24-hour excretion sample and checking the percentage of a test dose that is returned. Both oral and intravenous administration of the test dose are practiced. Others deplete the tissues first, and still others saturate the tissues before beginning the excretion studies. A simple technique of good repute for field work is the use of one-hour fasting urine. The latter was the technique used in this study. Table 12 shows the average excretion of the various vitamins in one-hour fasting urines and the percentage of subjects who excreted less than the normal amount.

Thiamine (normal range: 3.0-5.9 mcg. per hr.). Although the average for the entire group was well above the upper limits of normal, Table 12 shows that more than one third of the subjects excreted less than 3.0 mcg. of thiamine per hour. Of those whose excretion

21. H. E. Munsell, A. M. Cuadros, and R. M. Suárez, A study of plasma ascorbic acid values with relation to the type of diet used in Puerto Rico by groups of individuals of widely varied economic status. J.Nutrition, 28: 383–393, 1944.

TABLE 12

Urinary Constituents Excreted in One Hour

Constituent	*Pre-school Children*	*School Age Children*	*Men*	*Women*	*Average*	*Range*	*Percentage of Subjects Under Normal Levels*
Thiamine (Mcg. per hr.)	8.2	6.4	4.6	4.6	6.37	3.0–5.9	37
Riboflavin (Mcg. per hr.)	15.8	13.1	13.5	19.5	16.0	20.0–25	73
Niacin (F_2) (Quinine Units)	10.3	13.2	11.6	21.2	15.2	20.0–30	78

was satisfactory, 80 percent had low intake; on the other hand, 83 percent of those with satisfactory excretion also had low intakes.

Riboflavin (normal range: 20-25 mcg. per hr.). If one accepts the range of 20 to 25 mcg. per hour as normal for riboflavin excretion, then 73 percent of the subjects of this study excreted less than normal. Oldham[22] suggests 9 mcg. per fasting hour as an acceptable normal figure. Even by this much lower level, 41 percent of the subjects of this study excreted low levels of riboflavin. Of those cases whose excretion was below normal, 71 percent were accompanied by low intake. This poor condition was expected because of the very low intake of milk.

Niacin (normal range: 20-30 quinine units F_2). The metabolic end-product of niacin is known as the F_2 factor, or N-methyl-nicotinamide. The significance of its presence in urine is not perfectly established but, in general, it is believed to measure the degree of tissue saturation. Compounds, such as trigonelline, are sometimes associated with it and may cause a rise in the value of the F_2 factor. The data in this study are presented despite the unsettled state of their significance. Assuming for this study that 20 to 30 quinine units is the normal range, 78 percent of the subjects excreted less than the normal amount. Three fourths of those whose excretions were low also had low intake of niacin. Here, too, if the group as a whole is the unit instead of the individual, there is agreement between intake and excretion, for 78 percent excreted less than the normal quantity, and 78 percent consumed less than the recommended minimal amount of niacin. However, the individual intake and excretion showed little or no agreement.

22. H. Oldham, T. A. Johnston, S. Kleiger, and H. Hedderich-Arismendi, A study of the riboflavin and thiamine requirements of children of pre-school age. J.Nutrition, 27: 435–446, 1944.

Comparison with Other Studies

Comparison of these data with those of other studies reported within the year emphasizes the low values of the present survey. One report is from Newfoundland[23] where most of the food is imported. Another is from Mexico City[24] and deals with an economically poor group, whose income was only 15 to 35 pesos ($3.00 to $7.00) per month. These people participated in a regime of government feeding but before beginning the better diets, the data presented in Table 13 was obtained.

TABLE 13

Comparison of the Biochemical Data in Three Studies of the Nutritional Status of Widely Separated Groups

Biochemical Data	Present Study		Newfoundland Study		Mexican Study
	Average	Percentage Below Average	Average	Percentage Below Average	Average
Whole Blood					
Hemoglobin (G. percent)	12.7	31	13.1	19	14.6
Red cells (Millions)	4.2	64	N.R.[a]		4.6
Plasma					
Protein (G. percent)	6.6	23	6.9	2	7.5
Vitamin A (Mcg. percent)	17	83	22	74	25 (85 I. U.)
Carotene (Mcg. percent)	55	84	73	84	122
Vitamin C (Mcg. percent)	0.6	58	0.49	59[b]	0.81
Phosphatase	N.R.[a]		Normal		N.R.[a]
Urine					
Thiamine (Mcg. per hr.)	6.4	37	117[c]	69	N.R.[a]
Riboflavin (Mcg. per hr.)	16	73	437[c]	50	N.R.[a]
Niacin (Mcg. per hr.)	15	78	N.R.[a]		N.R.[a]

[a]N.R.—No report.
[b]Based on 0.4 mcg. percent instead of 0.6.
[c]Mcg. of vitamin to 1 g. of creatine.

As measured by the clinical findings, the Puerto Rican group was found in a lower nutritional state than either the Newfoundlanders or the poor Mexicans. Except in the case of vitamin C in the Newfoundland groups, the averages of all the blood constituents, which could be compared, showed the Puerto Ricans to have the lowest percentages. The averages for the urinary constituents could not be compared because different standards were used for normal, but the percentage of people below the normal, accepted in each study,

23. National Research Council, Medical survey of nutrition in Newfoundland. Canadian M.Assoc.J., 52: 227–250, 1945.

24. J. Calvo, G. Serrano, R. Segura Millán, F. de P. Miranda, and R. K. Anderson, Nutritional status of economically poor families fed in a government-operated dining-room in Mexico City. J.Am.Dietet.A., 22: 297–302, 1946.

showed that more Newfoundlanders had low thiamine excretions. The Puerto Rican percentage, however, was even greater with poor riboflavin excretion, in addition.

III. PHYSICAL EXAMINATIONS

As already mentioned, 157 individuals were examined—48 in the field and 109 in the clinic. Generally speaking, the poor nutritional state of these people was evident by the most casual observation. The children were listless and unresponsive; their faces bore the careworn appearance of the aged. Their arms and legs were shapeless and thin; their hair was dry and faded. It is true that such observations cannot be accepted as valid estimates of undernutrition; however, medical examination confirmed them.

Height and weight. When it is necessary to make a quick estimate of the nutritional status of a group, and it is possible to use only one criterion, the degree of underweight is the one most frequently chosen. This criterion must be supported by other evidence of malnutrition, of course, but it is one of the most apparent signs easily determined.

The height-weight measurements of this group were compared with two standards instead of one. As the inheritance of the Puerto Ricans limits their size, it was not valid to use continental standards. Therefore, the standards utilized were an American one, consisting of the Baldwin-Wood Standards for American Children, the Continental Life Insurance Tables for Adults, and a Puerto Rican one compiled from various source material. No perfectly satisfactory height-weight standards for Puerto Ricans were available. The most acceptable one for children was that of Salivia,[25] even though it is acknowledged to be based on an inadequate sample. The only one available for men was that of Morales Otero and Pérez[26] for agricultural workers. No tables were found for Puerto Rican women, therefore the averages used for them were interpolated from continental averages on the basis of the differences between the two standards for men.

Table 14 shows the degree and extent of underweight prevalent among the group studied.

When the continental standards were used, the underweight

25. L. A. Salivia, Estudio sobre la inspección médica en la Universidad de Puerto Rico y en las escuelas públicas de Puerto Rico. Bol. Universidad de Puerto Rico, diciembre 1934.

26. P. Morales Otero and M. A. Pérez, Health and socio-economic studies in Puerto Rico. III. Physical measurements of agricultural workers. Puerto Rico J.Pub.Health & Trop.Med., 14: 450–474, 1939.

TABLE 14

Height-weight Deviations from Normal

	Baldwin-Wood Continental Life Insurance Standards Percent	*Puerto Rican Standards Percent*
Overweight		
Over 10 percent	6	8
From 5 to 9 percent	5	10
Normal	27	36
Underweight		
5 to 9 percent	27	24
10 to 19 percent	27	21
20 to 40 percent	8	0

seemed to be more severe and more extensive than when the Puerto Rican standards were followed. Only 27 percent of the subjects were within the expected range for height and age by the first standard, while by the second, 36 percent were normal. Sixty-two percent by one standard and 49 percent by the other were more than 5 percent underweight. Perhaps a percentage of 5 to 10 of underweight is not serious, but certainly anybody who is more than 10 percent underweight must be considered malnourished. By continental standards, 35 percent of the people were more than 10 percent underweight, while this number was reduced to 21 percent if the Puerto Rican standards were utilized. Even a 21 percent incidence of such extreme underweight is a serious community health hazard.

IV. CLINICAL SIGNS

Malnutrition is indicated by many signs other than underweight. In this study, particular attention was given to the condition of the eyes, skin, lips, tongue, gums, and teeth, but space does not permit argument of the controversial nature of the evidences commonly found. However, the interpretations that have been generally accepted in other surveys have also been followed here. Table 15 presents the prevalence of the various signs observed.

Vitamin A. The particular function of vitamin A is to build new cells and, especially, to protect the epithelial tissue of the body wherever it may be found. Its lack causes atrophy, with substitution of a keratinized epithelium for the normal one. Insufficient quantities of vitamin A in man cause a dryness and roughness of the skin; it often becomes cracked and scaly, a condition known as ichthiosis.

TABLE 15

Prevalence of Signs of Malnutrition in a Group of 157 Subjects, Including 50 Pre-school Children

Signs of Malnutrition in Percentage of Group	*Pre-school*	*Total Group*
ASSOCIATED WITH VITAMIN A DEFICIENCY		
Eyes (conjunctiva)		
Thickened epithelium	12	69
Prexerosis	16	64
Bitot's spots	2	38
Skin		
Dry, scaly	8	9
Follicular hyperkeratosis	8	19
Ichthiosis		1
Total with one or more	38	79
ASSOCIATED WITH RIBOFLAVIN DEFICIENCY		
Eyes (conjunctiva)		
Hyperaemia or vascularity, Grade 1	32	15
Grade 2, or worse		77
Limbic Vessels		
Engorged	32	26
Twigs in transition zone	18	36
Twigs penetrating zone into cornea	0	6
Skin		
Sebaceous plugs at nasolabial folds	0	2
Lips		
Red and shiny	0	4
Angular cheilitis	0	9
Total with one or more signs	86	95
ASSOCIATED WITH NIACIN DEFICIENCY		
Skin		
Scars of healed pellagra	0	1
Tongue		
Hypertrophied papillae	22	25
Marginal glossitis	2	1
Furrows	0	1
Total with one or more signs	24	28
ASSOCIATED WITH VITAMIN C DEFICIENCY		
Gums		
Spongy, Grade 1	20	20
Grade 2, or worse	22	24
Miscellaneous infections	2	2
Total with abnormal signs	44	46
ASSOCIATED WITH GENERAL MALNUTRITION		
Teeth (particularly, calcium)		
One or more caries	36	54
Carious, and one or more lost		13
One or two plates		6
Total with defective teeth	36	73

The hair becomes dry and lusterless; papular eruptions about the hair follicles occur and gradually develop into spinous plugs, a condition known as follicular keratosis. Gastrointestinal disorders follow and, possibly, stones develop in the kidneys or bladder. Eye lesions are frequent, for absence of vitamin A produces xerophthalmia, keratomalacia, and night blindness. The signs of its shortage are the presence of "thickened, cloudy, dry, discolored conjunctiva, with or without a localized elevation including small foam-like plaques called Bitot's spots." Later, with longer and more severe depletion, xerosis of the cornea will occur.

Vitamin A is necessary in normal tooth development, particularly in the deposition of good enamel. The signs looked for in this survey, presumably associated with hypovitaminosis A, were the condition of the skin and eyes. Table 8, however, showed that 79 percent of the people had one or more signs suggestive of vitamin A deficiency. This is in good agreement with other observations made in the School of Tropical Medicine, where it was found that 95 percent of a series of 310 apparently normal subjects displayed poor adaptation to the dark,[27] and 59 percent of another series exhibited Bitot's spots. In a later study of hospitalized children,[28] it was observed that there were very few, if any, signs of vitamin A deficiency in the very young. The same observation was made in the present study, for children under two were free of such signs although 38 percent of those between the ages of 2 and 6 did have some signs. Of all who were free from vitamin A deficiency, 45 percent were under 2 years of age and 85 percent, under 4. It is apparent that in this group signs of deficiency developed with prolonged shortages, the young being better protected than the older people.

The vitamin A-deficiency signs have been grouped as mild or marked. Those subjects who had dry, rough skins and/or slight thickening of the conjunctiva were considered to have mild symptoms. If hyperkeratotic follicles, Bitot's spots, or a xerosis condition were found, it was considered as a marked sign of a deficiency state. On this basis, 66 percent showed signs of marked vitamin A deficiency. The data indicated high prevalence of avitaminosis A. No case of night blindness was encountered.

27. R. M. Suárez, Studies of the nutritional problem of Puerto Rico. I. Vitamin A deficiency in relation to dark adaptation and ocular manifestations. Puerto Rico J.Pub.Health & Trop.Med., 19: 62–80, 1943.

28. R. M. Suárez, Studies of the nutritional problem of Puerto Rico. II. Appraisal of vitamin deficiency on physical and biomicroscopic examination and X-ray studies of the long bones of a hospital population of 310 infants and children. Puerto Rico J. Pub. Heath Trop. Med., 21: 61–73, 1945.

Riboflavin. The signs commonly associated with ariboflavinosis are cheilosis—a reddened, shiny, thinly scaly appearance of the epithelium of the lips, with fissuring at the angles of the mouth (angular stomatitis); seborrheal skin lesions, particularly in the nasolabial folds, on the alae nasae, in the vestibule of the nose, and on the ears, and a special type of glossitis that is characterized by a purplish, or magenta-colored, tongue.

Occular changes also occur. These include conjunctival vascularization, and more especifically, a rough, burning, itching sensation accompanied by mild photophobia. The limbic vessels become engorged and corneal vascularization follows. There is also a condition of elevated follicular plugs across the nose and cheeks that is attributed to ariboflavinosis.

Although some of the signs just described have been reported as arising from other causes also, the evidence pointed strongly to the fact that their wide prevalence was caused by riboflavin deficiency, since they disappeared when the vitamin was administered.

The lesions found in this survey have been classified as suspicious, mild, and severe. The sign designated as suspicious was increased vascularity of the cornea; the mild signs included engorgement of the limbic vessels, as well as of the conjunctiva, and severe, included cheilitis, nasolabial plugs, and/or capillary invasion of the cornea proper. In this survey only 7 percent were free from all signs of riboflavin deficiency; 21 percent were suspects only; 67 percent had mild signs, and 13 percent showed signs of severe deficiency. This group demonstrated evidence of widespread indications of deficiency of this vitamin.

Thiamine. Signs of thiamine deficiency are not easily detected or measured, for the nervous system is primarily involved here. The emotions are first affected and then the tonus of the nervous sysem. Progressively there develops loss of appetite, quick fatigability, gastrointestinal disturbances, muscular weakness, pains in arms and legs, edema of the face and ankles, and a low blood pressure. In the more advanced stages, polyneuritis may develop with subsequent involvement of the entire nervous system. The data of this survey do not include records of these signs, for time did not permit of so extensive an examination. No case of beri-beri, however, was observed, and none of the subjects complained of pain in the extremities. Notwithstanding, neurasthenic symptoms that might be attributed to subclinical thiamine deficiency may have been present.

Niacin. Evidence of niacin deficiency is based on lingual symptoms and consists of a scarlet tongue, papillary hyperthophy, or at-

rophy of varying degrees. In this study, 26 percent of the subjects had some degree of inflamed papillae, while 22 percent were considered as mild. Although this deficiency is not as serious as other deficiencies, it is, nevertheless, fairly widespread. There were a few cases of apparently healed pellagrous skin lesions, but no active case of this disease was seen.

Ascorbic acid. The most reliable signs of ascorbic acid deficiency are found in the gums. Acute and subacute signs are apparent by the degree of redness, swelling, tenderness, and bleeding. Interdental papillae are lost, gingival margins become thickened, and there is a recession of the gums. Secondary infections readily develop. Among the persons examined, only 33 percent had normal gums. Forty-five percent had mild signs, or spongy gums, while 22 percent had marked symptoms with swelling and bleeding and, oftentimes, secondary infection.

Teeth. Although the cause and prevention of dental decay is a controversial problem, it is generally conceded that nutrition does play an important role in the development and maintenance of the teeth. Not only is an adequate supply of tooth-forming minerals necessary, but other constituents, particularly vitamins A and C, play important roles. Since calcium, vitamin A, and ascorbic acid were all low in these diets, one would expect the teeth of the subjects to reflect the consequent deficiencies. Dental caries were found in 52 percent of the cases; another 13 percent had lost one or more teeth, and 6 percent had one or two dental plates. With the dental condition of 71 percent of the people ranging from carious to no teeth, one is safe in saying that caries were widespread.

DISCUSSION

The data of this study show that both dietary and nutritional deficiencies were extensive and severe in the subjects studied.

The food supply was not only scarce but it was also poor in quality. With an average consumption of only 2.8 ounces of milk and 5.3 ounces of all fruits and vegetables, other than roots, deficiencies appeared in all nutrients. They were particularly serious in the cases of calcium, vitamin A, and riboflavin, where the intakes were 26,27, and 36 percent, respectively, of the recommended allowances. The per man-equivalent average for all nutrients was below that in the semi-starvation experiments of Keys'[29] and of the low-income groups of Mexico City.[30]

29. A. Keys, Human starvation and its consequences. J.Am.Dietet.A., 22: 582–587, 1946.
30. J. Calvo *et al.*, *op. cit.*

Good correlations between blood concentration and excretion levels of the vitamins and clinical signs of nutritional deficiencies were neither anticipated nor found. Structural changes of a tissue occur slowly once they are initiated. As with diseased conditions, there are periods of improvement and regression, but regression gains over the periods of improvement. During such periods of improvement or regression, the blood concentration is first affected, and very quickly. It takes time for the tissue to respond, so that blood concentration may possibly have changed again by the time the tissue begins to show effects of the deficiency. Animal metabolic economy has a way of conserving the nutrients that are provided and, on low intake, will hold its stores with remarkable tenacity by utilizing its supply with great frugality.

There are also conditioning factors that often intensify deficiency signs. Light is one such factor, causing increased vascularity that is not readily cured by the use of riboflavin. It is not to be expected, then, that perfect correlation between all the deficient signs can be obtained. Nevertheless, there was good agreement of the evidence of mass deficiencies.

Using the conservative minimal allowances for Puerto Ricans, 92 percent were deficient in dietary vitamin A, 83 percent in plasma vitamin A, and 79 percent showed one or more physical signs of vitamin A deficiency. By these same standards, 85 percent took less than the minimal allowance of riboflavin; 73 percent excreted less than normal; and 95 percent had one or more signs of ariboflavinosis. In the case of vitamin C, there were 48 percent of the subjects whose dietary intake was low, 58 percent whose blood level was low, and 46 percent who had physical signs of insufficient vitamin C. Dietary thiamine and excretion showed good agreement. Sixty-five percent had a low intake, while 37 percent had low excretion levels. In the case of niacin, 58 percent had less than the minimal allowance; 78 percent had less than the normal excretion level, and 78 percent showed signs of deficiency.

The nutritional status of these people is such that attention of welfare agencies should be directed to their problems. Basically, these problems seem to be financial, but they are also problems of education. Economically, these people need greater opportunity for work within an accessible radius; educationally, they need instruction in food values and proper choices within their budgets; they need instruction in planting and tending their gardens. Lastly, they must be stimulated to a willingness to use new foods, such as soybeans and parboiled rice, yellow sweet potato, and green and yellow vegetables.

SUMMARY

A survey of the dietary intake and nutritional status of a rural group in Puerto Rico is reported. The survey covered three aspects: (1) study of the dietary intake, (2) studies of the concentration of the constituents in blood urine, and (3) studies of physical signs of nutritional deficiencies.

The dietary studies showed that the diets were conspicuously low in calcium, vitamin A, and riboflavin, and that all of the other dietary essentials failed to measure up to the recommendations of either the National Research Council or to a more conservative standard elaborated for Puerto Ricans. These diets were conspicuously low in milk and yellow and green vegetables, which accounts for the inadequate levels of calcium, vitamin A, and riboflavin. The studies of the blood plasmas showed that less than normal concentrations of vitamin A and carotene were found in 83 and 84 percent of the subjects, respectively, while 58 percent were low in ascorbic acid.

Excretion studies demonstrated that less than normal quantities of thiamine were excreted by 37 percent; riboflavin, by 73 percent, and niacin, by 73 percent of the subjects.

Physical examinations revealed many signs of nutritional deficiencies. Sixty-one percent were more than 5 percent underweight; 73 percent had dental caries, or had lost some teeth; 79 percent had slight, or moderate, signs of vitamin A deficiency; 95 percent, of riboflavin deficiency; 28 percent, of niacin deficiency, and 48 percent, of vitamin C deficiency.

Correlations between dietary intake, plasma concentration, excretion level, and physical signs of deficiences could not be made, but there was general agreement between all aspects of the study that the nutritional status of the group was poor.

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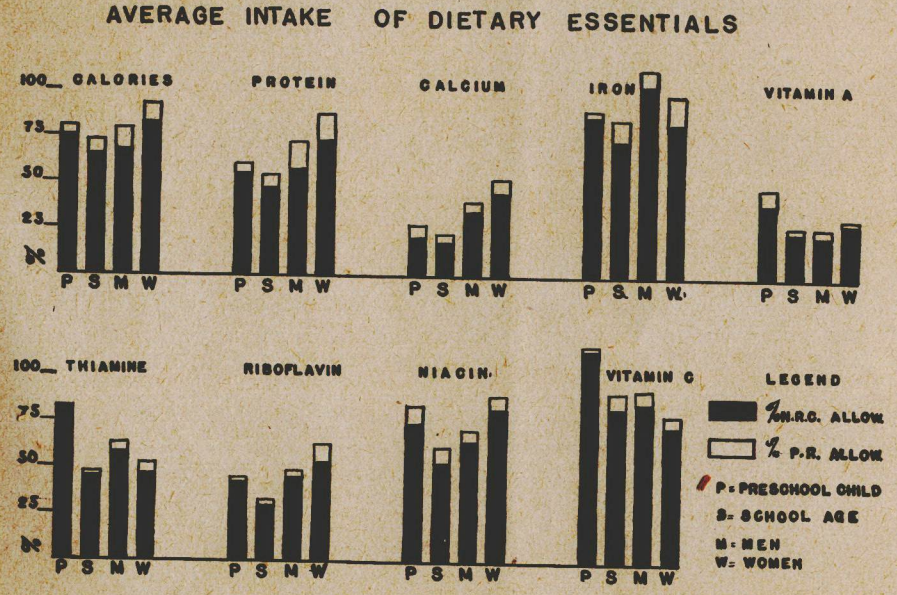

CHART 1

Average intake of dietary essentials as measured against the recommended allowances of the National Research Council and the revised Puerto Rican allowances.

GRÁFICA 1

Promedio de elementos dietéticos esenciales ingeridos, valorados de acuerdo con los patrones alimenticios recomendados por el *National Research Council* y con los patrones corregidos de Puerto Rico.

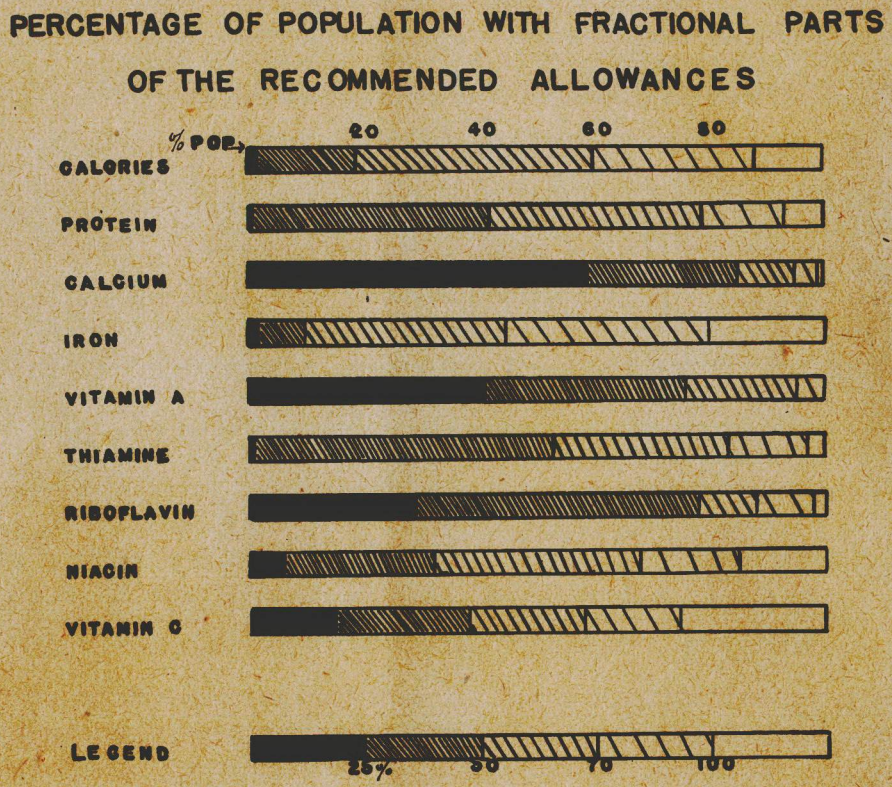

CHART 2

Percentage of population with fractional parts of the National Research Council's Recommended Allowances. The full bar represents the whole population and the shaded portions, the fractional part of the allowance.

GRÁFICA 2

Porcentaje de población con las fracciones de patrones recomendados por el *National Research Council*. La barra en negro intenso representa la población total y las porciones sombreadas, las fracciones de los patrones alimenticios recomendados.