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# Diet Supplementation for Entire Communities

## Growth and Mortality of Infants and Children[1]

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MORTALITY RATES of infants and children and the growth rates of survivors are reliable indicators of the state of social and economic development of populations. Although many environmental factors are involved, it is generally considered that nutritional state is most important, and that it in turn is dependent on the quantity and quality of food available and its distribution within the family. It is logical to assume, in attempting to cope with the poor growth and elevated mortality rates of children in the disadvantaged sectors of any society, that the provision of supplementary food of high quality deserves high priority. Consequently, it would be of great advantage to know something of the benefits to be expected from food supplementation to people living in otherwise unfavorable environments, with scant resources to better their own lot.

The results of a limited number of controlled attempts at supplementation are equivocal (1–4). Seven years ago we began such a study in Peru; the present report covers the most important observations. The optimism of our report after the 1st year of supplementation (5) has been tempered by a much longer experience.

### METHODS

Infant and preschool child malnutrition and elevated mortality rates are the rule throughout most of Peru (6). In choosing study populations we eliminated large urban slums and a number of available rural populations because of the futility of attempting a long-term study with any semblance of controls. We selected a sugar plantation in northern Peru because of its isolation, the high degree of interest expressed by the owners and by the leaders of the labor union, and an incidence of malnutrition and mortality rates that seemed susceptible to clear-cut improvement, despite their being considerably lower than those of other available populations.

The plantation selected had a total population of approximately 13,000 people, 9,500 of whom lived in the areas immediately adjacent to the mill and the remaining 3,500 in four relatively remote subdivisions, each one of which had originally been a separate plantation and had retained much of its independence, with relatively little exchange between them. The fact that the four subdivisions were under the same management, were of similar ethnic origins, had similar sizes (600–1,150 inhabitants), age distributions (50% under 16 years of age, 25% under 7 years of age), occupations, housing conditions and wages, and received part of their pay in food, made us

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confident that we could introduce a single variable into one or more of the four groups and leave the remaining ones as reliable controls. Distances of 5–10 miles separate each population and transportation facilities are very limited, with social intercourse at a minimum. They are here designated as *populations I, II, III,* and *IV*.

A complete census and anthropometric measurements of all residents in *populations II, III,* and *IV* were first carried out between April and July of 1962. Because of the lesser heights and weights of its children, *population IV* was intentionally singled out for the most complete supplementation. The census and measurements of *population I* were first taken in May and June of 1963. After the first measurements were made in each group, they were repeated for all residents at least twice a year, at the end of the summer (March–April) and at the end of winter (September–October).

Throughout this report the heights and weights of all the children are expressed as "developmental quotients." Arbitrarily taking the 50th percentile of an internationally known United States growth standard (7) as the reference, each measurement is converted to a "developmental age," the age to which it corresponds on the appropriate reference curve. This developmental age, divided by the chronologic age and multiplied by 100, becomes a "developmental quotient." Thus, a boy 2 years of age with a weight of 10 kg would have a weight quotient of 50, as this weight corresponds to that of a 1-year old boy on the United States reference curve. These quotients permit the presentation of heights and weights in the same units and the averaging of boys and girls of different ages. It should not be assumed that the 50th percentile of this or any other United States standard represents the true genetic potential of this Peruvian mestizo population. This is not known, but is probably significantly less.

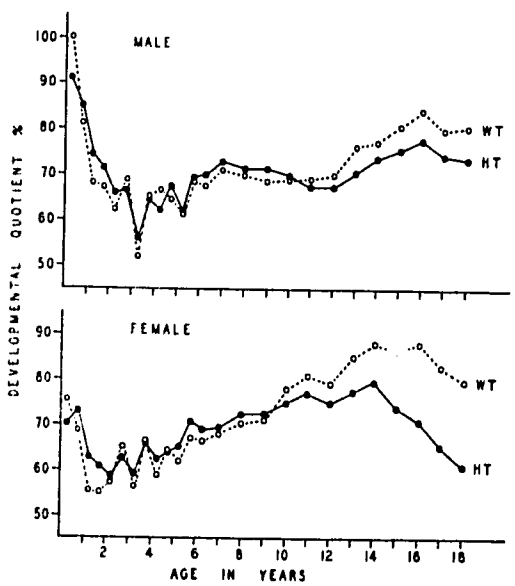


FIG. 1. Mean developmental quotients for height and weight from birth to 18.5 years of age for males and females of all four populations at beginning of study.

Figure 1 depicts cross-sectionally the mean developmental quotients for height and weight of all boys and all girls from the four populations combined, at the time of their first measurement. During the first 6.5 years of life the children were grouped into 6-month categories. The first points, plotted at 3 months of age, correspond to all boys or all girls between birth and 6 months of age. From 6.5 years on they were grouped in yearly intervals until 18.5 years of age. Thus, the points at 7 and 18 years of age correspond to all children between 6.5 and 7.5 and between 17.5 and 18.5 years of age, respectively. These curves reveal growth patterns that are characteristic of most of Peru and many underdeveloped countries: *1*) a dramatic fall in the quotients between 6 and 36 months of age for both sexes, *2*) a seemingly more rapid recovery for girls, reaching a peak at 14 years, by which age nearly 100% have reached the menarche, *3*) an apparently precipitous drop after this age, due to the fact that many girls in the United States have not yet matured and are still growing at an accelerated rate, and *4*) a more gradual but prolonged recovery in the boys, reaching its peak at 16 years of age.

*Population I* remained as a control during the entire study. It, along with the other three, received some medical assistance from our staff, the regular care being provided by the plantation.

*Population II* also served as a control, with the exception of a feeding program for the 6- to 30-month-old children, which began in 1965 and will be the subject of a future report.

In September of 1962, immediately after the second measurements, *population III* began to receive a free supplement of ordinary white

wheat flour noodles, 500 g a week for each member of the family. At least one-half of the weekly supply, picked up by a member of the family at a central distribution point, was in the form of fine "angel's hair" noodles, a form traditionally fed to small children and one of the few solid foods ever fed to infants. Assuming even distribution within each family, this should have represented an "addition" of 250 kcal and 7.5 g of protein to the daily intake of each member.

At the same time the inhabitants of *population IV* began to receive an equal amount of noodles made from white flour enriched with 10% fish protein concentrate (FPC) containing approximately 80% protein. As a result the "addition" to the daily diet consisted of 250 kcal and 12.5 g of approximately equal parts of wheat and fish proteins. The source of FPC was principally the pilot plant created in Quintero, Chile, by UNICEF, but at various times we used FPC from the VioBin Corporation in Monticello, Illinois, and from the Bureau of Commercial Fisheries in College Park, Maryland. Noodles made with 10% FPC from these sources have been shown to be adequate as the source of protein in the diet of infants and small children (8).

In both populations, 95–98% of the families picked up the noodles every week and after some initial difficulty in devising ways of incorporating the large amount into their diet, consumed them regularly and completely. This was verified by frequent unannounced visits to the homes, particularly at meal times. At the time of these visits, estimates of total food consumption indicated that the "supplements" were displacing other foods, particularly cassava and sweet potato. In December of 1967, after more than 5 years, the supplementation was discontinued.

## RESULTS

Figure 2 depicts the evolution of height and weight quotients of children in the four populations during the 6-year period beginning a few months before supplementation was begun and ending a few months after its discontinuation. For each population, boys and girls combined were divided into three age categories. Infants below 6 months of age were excluded because of the extreme variability of their quotients. The first age category, loosely called "preschool children," includes those between the ages of 6 and 77.5 months at the time of each measurement. The second category, called "schoolchildren," includes those between the ages of 78 and 149.5 months. The third category, loosely called "adolescents," includes those between 150 and 221.5 months of age. It is apparent that in this system the group of children being measured in each age category was constantly changing, with some entering and some leaving between each measurement.

Figure 2 reveals seasonal variation in the weight quotients of the preschool children of all four populations, becoming less obvious in *population IV* during the last 4 years of the study. This same variation, a significant gain during the winter and a similar loss during the summer, is apparent in the adolescent *populations I* and *II*, but not in those of *III* and *IV*, nor in any of the schoolchildren. Similar variations have been reported before (9, 10).

There appears to have been an impressive gain in the height quotient of the preschool children of *population IV* during the 1st year of supplementation and a steady gain in their weight quotients during the first 3 years. There was a steady gain in the height quotients of the two control populations of the same ages and irregular but definite gains in weight.

In the schoolchildren of all four populations a remarkable consistency in the height and weight quotients throughout the 6 years is apparent. The children of *populations I* and *III* were moderately taller at all times, and their weight-to-height relationship was indicative of some degree of obesity, suggestive of a more generous calorie intake. The children of *population IV*, initially shorter and slightly "underweight," remained shorter but gained in weight. The children of *population II*, one of the controls, evolved in exactly the same manner.

The adolescents were consistently "over-

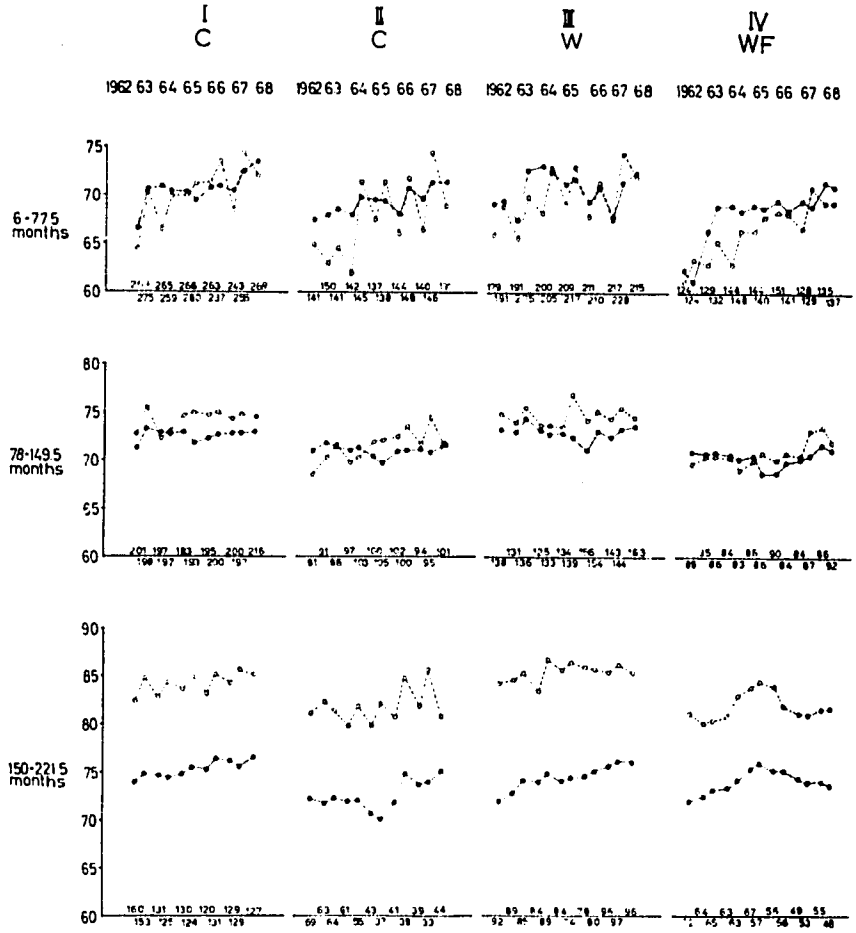


FIG. 2. Mean developmental quotients for height (closed circles, solid lines) and weight (open circles, broken lines) of all boys and girls in each age category at the time of each semiannual measurement in each of the four populations: *I* and *II* served as controls (C), *III* received wheat (W), and *IV* received wheat and fish (WF) supplements. Figures along the base line indicate number of children measured each time.

weight" throughout the study, with no discernible effect of supplementation. The gain in the height quotients of *population III* was nearly matched by that of *populations I* and *II*.

The heights and weights of the adults (18.5 years or older) of all four populations were followed. Initially, the mean heights of the men (approximately 158 cm) and of the women (approximately 146 cm) were nearly identical for all four groups. At the end of the study the mean height of the men in *population I* (160 cm) was slightly greater than that of *populations III* and *IV* (159 cm) and *population II* (158+ cm). The same slight advantage was apparent in the heights of the women: 147.5 versus 147 and 146.5 cm. Initially the mean weight of the men in *population IV* (55.3 kg) was less than that of *populations II* and *III* (56.5 kg) and *population I* (58 kg). After 6 years the men of *population IV* had equaled the mean weight of those in *population II* (58.4 kg) but still lagged behind those of *populations III* (59 kg) and *I* (60 kg). For the women, the initial weight in *population IV* (48 kg) was also lower than that of *populations II* and *III* (50.5 kg) and *population I* (53 kg). After 6 years the mean weight of the women

in *population IV* (51 kg) was still below that of *populations II* (53 kg), *III* (53.8 kg), and *I* (56 kg). It would seem that there was an upward trend in all four populations.

The seemingly insignificant effects of supplementation on the growth of the children, which is apparent from the above analysis, led to additional examination of the data.

When the figures for infants between the ages of 6 and 30 months were separated from those 30–77.5 months of age, the same trends described for the larger group were still apparent.

Because the mean quotients for each group had included all children examined on each occasion and were made up of constantly changing populations, it was decided to plot longitudinally the quotients of those children who had missed no more than one measurement. This was done in Figs. 3 and 4, with the sexes separated, for the children who were in each of the

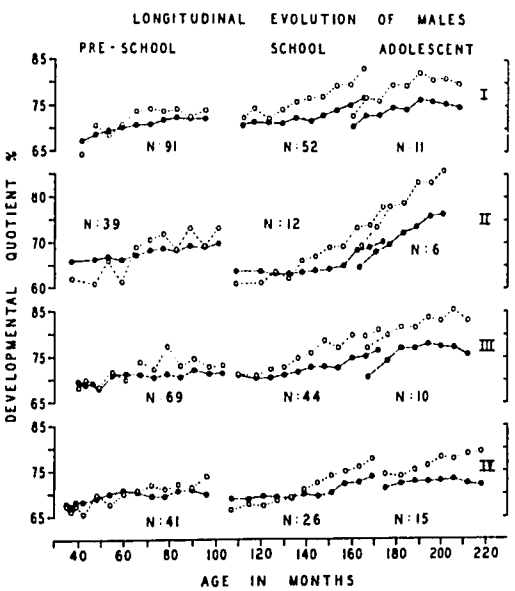


FIG. 3. Mean developmental quotients for height (solid lines) and weight (broken lines) of boys from each population (*I–IV*) who were in each of the three age categories at the time of the first measurement and who were measured regularly on a semi-annual basis thereafter.

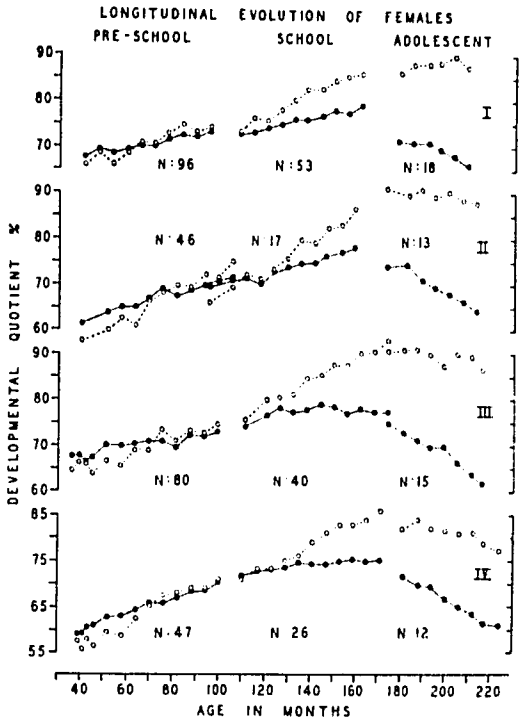


FIG. 4. Mean developmental quotients for height (solid lines) and weight (broken lines) of girls from each population (*I–IV*) who were in each of the three age categories at the time of the first measurement and who were measured regularly on a semi-annual basis thereafter.

three age categories at the time of the initial examination. They are carried through each examination, becoming 6 months older at each succeeding point. These curves are comparable to the corresponding segments of Fig. 1. Because of the manner of selection and the separation by sex, the number of children followed in each point of the two figures is approximately 25% of that in each point of Fig. 2.

Figures 3 and 4 reveal similar patterns in all four populations. At the end of 6 years, the mean age of those who began in the preschool category was similar to the initial age of those who began in the school age category and for these in relation to the adolescents. The final quotients of each group were superior to the

initial ones of the next, suggesting a constant improvement in growth.

The cross-sectional (Fig. 2) and the longitudinal (Figs. 3 and 4) evolutions were plotted using the mean quotients. When the median values were plotted (not illustrated) instead, the lines were a bit smoother but nearly identical in their trends.

Although we had an accurate census of each population for the 12 years preceding this study, the data on live births were of dubious value, most of them occurring at home. The data on infant (0–12 months) and preschool child (12–60 months) deaths were more reliable and we were able to reinforce them when the original census and measurements were carried out. All the data for the years 1962–1967 are reliable.

Table 1 presents the infant and preschool child mortalities for the years 1950–1967. For the first 12 years they have been related to population; for the 6 years of study they have been related to population and to the number of live births. Prior to our study, *population I* had an infant mortality which was significantly ($P < 0.02$) higher than that of *population III;* none of the other differences, either for infants or preschool children, were significant. During the 6 years of supplementation the differences in infant mortality between either one of the two control groups and either one of the two supplemented groups were highly significant, when expressed per 1,000 inhabitants or per 1,000 live births. Although *population I* had a significant improvement in its previously high infant mortality, this did not match those of *populations III* and *IV*, both equally impressive.

The preschool children of *populations III* and *IV* experienced impressive declines in mortality during the 6 years of study but only that of *population III* was highly significant. A similar, but not as impressive, decline was apparent for the two control populations. Whereas in 1950–1961 there had been no difference between the four groups, in 1962–1967 the difference between *groups I* and *III* approached significance ($P < 0.1$). When the two control populations and the two supplemented populations were combined, the differences for the 1962–1967 period (not in the table) were

TABLE 1

Infant (0–12 months) and preschool child (12–60 months) mortalities in the four populations during the 12 years preceding the study and during the 6 years (1962–67) of supplementation of *populations III* and *IV*

| Age group, months | Years | Populations | | | | *P* Values | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | I-III | I-IV | II-III | II-IV |
| | | Deaths/1,000 inhabitants | | | | | | | |
| 0–12 | 1950–1961 | 8.2 ± 2.4 | 6.1 ± 4.9 | 5.0 ± 3.2 | 7.0 ± 3.7 | <0.02 | NS | NS | NS |
| | 1962–1967 | 5.2 ± 1.9 | 8.3 ± 3.7 | 2.0 ± 1.1 | 2.5 ± 1.4 | <0.01 | <0.02 | <0.01 | <0.01 |
| | *P* | <0.05 | NS | <0.05 | <0.02 | | | | |
| 12–60 | 1950–1961 | 5.3 ± 3.6 | 3.3 ± 3.3 | 4.0 ± 2.6 | 3.5 ± 3.3 | NS | NS | NS | NS |
| | 1962–1967 | 2.3 ± 1.9 | 1.8 ± 2.3 | 0.7 ± 0.6 | 1.3 ± 1.1 | <0.1 | NS | NS | NS |
| | *P* | NS | NS | <0.01 | NS | | | | |
| | | Deaths/1,000 live births | | | | | | | |
| 0–12 | 1962–1967 | 104 ± 37 | 165 ± 95 | 44 ± 25 | 52 ± 32 | <0.01 | <0.05 | <0.02 | <0.05 |
| 12–60 | 1962–1967 | 46 ± 39 | 34 ± 39 | 17 ± 13 | 26 ± 21 | NS | NS | NS | NS |

significant ($P < 0.05$), whether per 1,000 inhabitants or per 1,000 live births.

At about the time of the initiation of our studies, unknown to us, the owners of the plantation had made a decision to eliminate *"village" IV* and to eventually move its inhabitants to *villages II* and *III*. As a result, important improvements in housing and sanitation that were made in the other three areas were not made in *village IV*, which initially had inferior conditions.

## DISCUSSION

During a period of a little over 5 years we "supplemented" the diet of all the members of two similar populations, leaving two additional groups as controls. The foods provided were of equal caloric value, but that provided to one of the populations had almost twice the protein content and this was of superior biological value. Nevertheless, when the results were analyzed, there was no clear advantage to the superior protein intake. The results of the supplementation can be summarized as follows:

*1*) The supplement, probably because it was in the form of a "prestige" food, was consistently well accepted and consumed, apparently displacing foods of lesser nutritional value.

*2*) There was a similar increase in the mean heights and weights of the adult men and women of all four groups, apparently independent of supplementation and suggesting that the adults of the supplemented groups had not appreciably increased their total calorie intake.

*3*) There was appreciable improvement in the developmental quotients for height and weight of the preschool (6–77.5 months) children of all four populations, particularly in the two groups (one supplemented, the other a control) who were less well off initially. Although there were improvements in the environment of the other three groups, and not in this supplemented group (*IV*), which might have resulted in better growth, we must be cautious in attributing the gains of this last group to supplementation alone.

*4*) There was no change in the quotients of the school age (78–149.5 months) children in all four groups. Their remarkable stability is probably the result of relatively slow growth at this age, of a previously adequate food supply, and of substitution instead of supplementation. This tends to cast doubt on the value of school lunch programs, the most common form of supplementation throughout the world.

*5*) A modest but steady improvement in the height quotients of the adolescents (150–221.5 months) was apparent in all four groups, who were already overweight.

*6*) There was marked seasonal variation in the weight quotients of the preschool children and adolescents of the control populations, not so in the school-age children. It was also apparent in the preschool children of *group III* and to a lesser degree in those of *group IV*. It was not present in the adolescents of either group. This difference suggests that the supplements, particularly the protein-rich one, did achieve some stabilization of the food supply.

*7*) Despite the disappointing effect on growth of the children, this form of supplementation was associated with an impressive decline in infant mortality and an important decline in preschool child mortality, suggesting that the total calorie intake remained unchanged but that the supplements displaced foods of lower biological value.

It is tempting to "rationalize" our apparent failure to improve the growth of the children in the supplemented groups, and we can indeed find some reasonable explanations.

*1*) The effective calorie intake and consequently the rate of growth is a function of the total environment and is not

easily influenced, unless it is near famine levels, which was not the case. High mortality rates can be lowered by improving the quality of food available.

2) Groups of people who are seemingly very similar can turn out to have important differences (11). This is probably true of our populations.

3) It is conceivable that the improvements in *group III*, and particularly in *group IV*, were the result of supplementation and that those of the control groups resulted from other causes. It would thus seem that the inhabitants of this last area, as a result of our supplementation, improved their nutritional status despite a more hostile environment.

This study suggests that if dietary supplementation is to succeed, it should take the form of a food with prestige value that is commonly used by that segment of the population that one hopes to reach. In addition, it demonstrates some real benefits (decreased mortality rates among infants and probably preschool age children) while confirming the difficulties that are likely to be encountered in a field trial of the value of supplementary foods. Without adequate controls it is virtually impossible to give a valid interpretation to results obtained in this type of study.

## SUMMARY

Two populations with high infant and preschool child mortalities and poor growth in early life were given additional food, equivalent to 250 kcal/person per day for over 5 years. One received 7.5 g/day of wheat protein and the other 12.5 g of equal amounts of wheat and fish proteins.

There was an impressive (more than 60%) decline in the infant and preschool mortalities of both study populations. Although there was measurable improvement in the growth of children, an equally favorable trend was apparent in two similar control populations, but without a significant decline in infant mortality and only a modest decline in that of preschool children.

The difficulties encountered in field trials and the necessity for adequate control populations are brought out by these results. Unless near-famine conditions prevail, food supplements are most likely to displace other foods, hopefully of lesser biological value. With this in mind, they should be as complete as possible. Total effective calorie intake is not easily increased.

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