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“Malnutrition”: An Intellectual Odyssey

David Seckler

When President Young asked me to address this meeting of the Western Agricultural Economics Association on my work in nutrition policy I gladly accepted for I have been spending most of my time talking to nutritionists about these problems and perhaps not enough time talking to my fellow agricultural economists. I say this not only because of the obvious connection between nutrition, food policy and agriculture but because of a discovery, in my opinion, of considerable consequence. This discovery is that the concept of “malnutrition” cannot be comprehended except in terms of the economic theory of optimality.

In order to understand what I mean by this statement it is first necessary to understand “malnutrition” is an extremely ambiguous word. The Random House Dictionary, for example, defines “malnutrition” as “lack of proper nutrition.” Since “proper nutrition” is not defined, one must simply assume that it is “lack of malnutrition”. As Ford observes,

“The term ‘malnutrition’ has been in use for a very long time and appears to be self-explanatory but even the briefest perusal of the vast literature on nutrition raises grave doubt about that. There is no way of knowing if the word has the same significance in all parts of the world or if its interpretation lies, like beauty, in the eyes of the beholder. . . . Anything less scientific than this chaotic inexactitude would be difficult to imagine.”

The problem is that there are two quite different criteria of “proper nutrition” and

“malnutrition”. Under one criterion proper nutrition is defined as sufficient intake of nutrients to reach the full genetic growth potential of the individual defined by various anthropometric and nutritional standards. Malnutrition then becomes abnormally low size and/or consumption. Under the second criterion, malnutrition is defined in terms of certain clinical signs of nutritional inadequacy and/or indices of functional impairment, such as the inability to work productively. Proper nutrition then presumably becomes the absence of these clinical-functional signs of malnutrition. The problem is that most of the people who are not “properly nourished” under the first criterion are also not “malnourished” under the second criterion! There exists a considerable “grey area”, consisting of perhaps as much as 80% or more of the conventionally estimated world of malnutrition, who are *neither* “properly nourished” nor “malnourished”. They are simply “Small but Healthy” people who have attained an optimum size with respect to their environment.

In the course of the following discussion I would like to describe how I arrived at this conclusion — my “Intellectual Odyssey,” as I have called it. I have chosen this mode of presentation primarily because it appears to me to present the most convenient format for reducing a rather lengthy research effort to a short discussion; but also, because I am interested in the philosophy of science, and I have personally found the process of “conjecture and refutation”, as Karl R. Popper describes it, over these past three years one of the most exciting intellectual episodes of my life. Thus I will speak some of my personal experience and to those who think this has no place in academe I can do no

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better than cite our colleague William Foltz who once said in introducing his remarks on a paper he was about to review, "Gentlemen, I apologize for citing my personal experience — but, Gentlemen, it is the only experience I have had."

Nutritional "Requirements"

My interest in nutrition began in the summer of 1977 when I was in India on a short-term consulting assignment to the Central Soil and Water Research Conservation and Training Institute, Dehra Dun. The assignment, I thought, was quite simple: to do economic evaluations of various projects of the Institute in rather remote and isolated areas of India, particularly in the "hill areas" of the Himalayas.

The specific problem I encountered was that in the highly underemployed and poverty stricken area of the hills — and, I later found, generally throughout India — people would not work for less than about Rs.5 (or 60¢) per day. I thought it peculiar that people appeared to be willing to starve rather than work for this, under Indian conditions, not inconsiderable wage. The fact of this wage floor was of course of considerable importance to my evaluations because while it is conventionally assumed that the shadow price of labor under conditions of unemployment is zero, or near zero, this fact seemed to me to indicate that there was a real cost of labor keeping this wage floor in place. Let me say at the outset that I do not believe that "culture" or "work-leisure" preferences are very relevant in this domain of abject poverty. Something more fundamental, I suspected, was going on.

It is clear that the physical energy expended in physical work must be provided by the physical energy provided by food. Thus there must be a fundamental connection between earnings, which are used mainly to purchase food, and the energy requirements of the work required to obtain earnings. I thought I would spend a few days working this little problem out and here I am, three years later,

still in this most fascinating field of nutrition.

I estimated that a representative household of Indian agricultural laborers consisting of 5.33 people would generate about 776 days of work per year under full employment [Seckler]. In order to meet their energy requirements at this level of work they would require about 4,245,000 kcal. per year — or, at 3,150 kcal. per kg. of wheat, about 1,350 kg. of wheat per year. The poor Indian household spends about 60% of its income on foodgrains, 20% on other food items, and 20% on non-food necessities such as clothing, shelter and fuel. Thus to meet all necessities it must earn about 2,000 kg. of wheat or equivalent per year. At full employment, the daily minimum foodgrain wage would be 2.6 kg. Assuming men earn 20% more than women, the minimum male wage rate would be 2.9 kg. of foodgrain. I later found that this estimate corresponds remarkably close to Clarke and Haswell's survey of agricultural wage rates in subsistence economies. They observed, "...the strange fact...that, throughout all times and places for which we have information, the rural laborer, however poor, will not do a day's work for less than three kilograms grain equivalent."

It is difficult to convert this minimum foodgrain wage to monetary terms without detailed knowledge of local diets and costs of foodgrains and other necessities. However, following Dandekar and Rath's estimates for rural India 1969-1970 and adjusting for inflation to 1977 I found that the Rs.5 figure was perhaps as close as one could conceivably get. I concluded that the energy-work connection is indeed decisive in setting such floors as I had observed.

The one snag in this conclusion was that the Rs.5 figure was based on the assumption of a fully employed household. If unemployment existed in the extent of 20%, with only 600 days of work per year, the minimum daily wage would have to be about Rs.5.8 or 16% more than the observed floor (the relation is non-linear due to savings of calories and other necessities in unemployment).¹ For reasons explained below, I later discovered

that I had overestimated kcal. requirements and thus, the Rs.5 figure was probably about right *with* 20% unemployment.

From this point I naturally became interested in the mechanism through which this apparently universal minimum foodgrain wage would be established. The classical theory of the subsistence wage immediately comes to mind. But this theory is a long-run theory depending on the regulation of the aggregate supply curve for labor through attrition of children and, while obviously true as a long-run phenomena, it did not appear to me to be adequate for the essentially short-run, nearly day-to-day equilibrium which I seemed to detect in the case even of the individual household.

The answer to this problem is quite specific and direct in the nutritional literature. In the classic starvation studies of Keyes, there is shown a very clear production function between energy intake and work ability and work performance. Interestingly, under starvation work performance decreases *before* work ability due to the mental and emotional stress of deprivation. There is no time here to review this long and fascinating study but I would like to say that if you want to understand the "economics of being poor" which, I agree with Shultz, is the only economics that really matters, you should study Keyes. As a laborer's wage goes below 3 kg. per day under the competitive pressures of underemployment his productivity decreases. As his productivity decreases there is more downward pressure on his wages as the employer tries to pay him *at most* the value of his marginal product. However, this vicious cir-

cle must soon end because the laborer "gets sick". The body throws out a complex variety of defensive mechanisms: slowness, drowsiness, lethargy, stumbling, and fainting (quite a common sight in Indian fields) — which causes the laborer to be dismissed. As more of the laboring class is disabled by low wages a labor shortage develops and wages are restored to their energy equilibrium level. Of course there is nothing above equilibrium in this model to stimulate a higher wage because once the laborer can purchase enough energy to do the work, the marginal product of the energy-wage is zero.

This analysis seems to me to be perfectly satisfactory but it depends on one crucially important and, I find, entrancing assumption. This assumption is that the wage-earners in a household love their dependents to the extent that they will, in a sense, "irrationally" share their scarce food supplies with their dependents in proportion to their needs. The 3 kg. equilibrium figure assumes that the wage earners *do not* make their dependents bear the nutritional burden of low wages. If they treated the dependents as residual claimants on scarce food supplies, as is commonly thought, the equilibrium wage would be much lower than 3 kg. per work day. In principle it would reduce, as the dependents died off, to about 1.8 kg. It is reasonably certain that sharing takes place because the poorest and most malnourished households are also the largest households. I have tried to check this sharing assumption in detail by examining data on the age and sex distribution of anthropometric indices (weight, height, weight for height, etc.) in poor Indian households relative to received anthropometric standards. My tentative conclusion is that except for underestimation of the additional nutritional requirements for growth of children, and the additional requirements of pregnant and lactating women, the gap between anthropometric reality and standard is *uniform* across age and sex groups within the household. The household, in other words, attempts to share the burden of malnutrition as uniformly as they

¹Since 80% of the nutrient requirements for a household are fixed requirements on an annual basis, the wage floor supply curve is downward sloping with respect to days worked per year. Thus one would expect a decrease in daily wage rates as more employment per year is offered up to the inelastic portion of the supply curve. The green revolution may have this wage rate depressing, but income raising, effect in the early stage of its development with wage rates rising, if ever, only in the later stages as regional labour shortages develop.

can estimate — and, indeed, for reasons outlined below, they possibly estimate requirements for the special groups more rationally than do nutritionists. One of the more provocative results of this preliminary analysis is that by anthropometric criteria, the female members of the typical Indian household appear to be slightly better off than the males. I have received a few arrows of outrageous fortune for corroborating the intuitively obvious fact that fathers and husbands do indeed love daughters, wives and mothers.

With these general conclusions I completed what I now look back upon as Phase I of my work in nutrition. But it soon became obvious that there remained a basic problem in this position which launched me into a much deeper study of nutrition than ever I had contemplated.

“Small but Healthy”

The Phase I problem was this. If one takes the commonly accepted energy requirement of 2,250 kcal. per capita per day for the Indian population, converts this figure into earnings, in the manner indicated in the preceding section, and then estimates the incidence of malnutrition in India as those below a certain minimum earnings, one finds, as Dandekar and Rath have shown, that about 40% of the rural population of India do not earn enough to meet minimum calorie requirements. This conclusion is not extraordinary in itself. India is a poor country. But the extraordinary thing is that if one calculates out the degree, or severity, of malnutrition in India, one finds that nearly 20% of the rural households do not earn enough to meet minimum necessities, provide their energy maintenance costs, and *do any work at all*. In India, if poor people cannot work they cannot survive. I considered this fact a refutation of the quantitative basis of my previous position. There were only two possibilities I could see: either the method of estimation was incorrect; or the 2,250 kcal standard was too high — or, as I have since concluded, both.

I shall not go into the estimation problem here as it would require too much time. Rather, I shall concentrate on the problem presented by the 2,250 kcal. requirement. Here it is important to note that I have only a superficial knowledge of the bio-chemistry of nutrition so that my arguments are only those of an economist, together with some rather common observations available to everyone (except, it sometimes seems, to nutritionists!).

One of the many pleasant surprises of India is that as one travels through the country one simply does not see anything like the extent of malnutrition one expects to find from the available data, much less the popular press. Not being a trained nutritionist I cannot trust my own observations so I make a habit of asking trained people to estimate the incidence of severe malnutrition in the populations in which they work. With the exception of an area in eastern U.P., which is generally considered one of the worst areas of India, the response varied from 1% to 3% of the population. In the U.P. area it was 20%. This seems to me to be an extraordinarily small incidence of severe malnutrition in a population which is presumed to be 40% malnourished.

I might pause here to mention that there is a considerable body of opinion that in most areas of rural India there has been a notable improvement in the nutritional status of people over the past decade even though per capita food consumption has remained the same or even decreased. While this opinion is not universally held, I believe that it is probably valid. There are two reasons for this belief. First, the enormous advances in control of diseases and extension of medical services discussed by Ram and Schultz, have undoubtedly increased the efficiency of conversion of food input into output by lowering the amount of “food wastage” through diarrhoea and other health factors. (Also, there is the common mistake of diagnosing symptoms of diseases such as the “pot belly” of malaria with malnutrition.) Secondly, it is possible that since the marginal propensity to con-

sume food is very high in India, real gains in agricultural production are underestimated by food disappearance in home consumption and by upgrading food products — i.e., converting foodgrain into milk products or better qualities of foodgrains. But this is a problem I cannot examine further here.

While one does not see a great deal of visible malnutrition in India, one does see a lot of extremely small people — and the poorer people are, the smaller they tend to be. As one of my friends has observed, small people seem to do all the heavy work in India, including carrying the luggage of large people at Delhi airport!

Now this is a very important fact, if it is a fact, because the nutrient requirements of an individual of given sex, age and activity level are a function of body surface area — or, approximately, of weight. It follows that if the poor weigh less than the weight assumed in the calculation of nutrient requirements, their real nutrient requirements will be less than their assumed requirements at any given point in time. I have been tracking this thin red line through the nutritional literature for the past two years and have concluded that most of the people of the world who are considered malnourished are simply “Small but Healthy” people.

This conjecture may be illustrated by some statistics from a recent study of nutrition in the five poor countries of Nepal, Sri Lanka, Togo, Liberia, and Lethsoto [McKigney]. The incidence of malnutrition by anthropometric criteria ranged from about 55% in Nepal to 20% in Liberia. However, about 90% of all the malnutrition found in these countries involved people with low height for age *but with the proper weight for height ratio*. Now, if one thinks of malnutrition in the conventional imagery of thin, wasted bodies, rather than in terms merely of short people, the incidence of malnutrition must be considerably reduced. Of course since short people with the proper weight to height ratio will also be light people, their consumption requirements will also be less than conventionally estimated.

One naturally wonders if there is anything wrong with these small people other than their smallness. Oddly enough, there has been very little study of these “mild to moderately malnourished” (MMM) people. Jelliffe observes,

“In as yet ill-defined circumstances, protein-calorie malnutrition — probably when mildly moderate and prolonged — results in nutritional dwarfing — that is, in children who are “considerably underweight and undersized, while at the same time appearing to have relatively normal body proportions.” (Jelliffe, 1959). As Downs (1964) remarks, children with nutritional dwarfing are light in weight, short in stature, with relatively normal body proportions and sub-cutaneous fat appropriate to their weight; they are likely to be taken for healthy younger children.”

“This condition has received inadequate attention but appears to be common in Peru (Graham, 1966) and in Arab refugee children in Lebanon (Puyet, Downs and Budier, 1963, Downs, 1940).”

There is a haunting picture in Jelliffe's excellent book which shows two babies of the same height, yet the one is six months old and the other eighteen months old. The eldest “looks”, if anything, better than the youngest. Looks are deceiving, but the caption does not indicate any difference between these babies other than age and, as Jelliffe indicates in the above citation, if one does not know the age of these “nutritionally dwarfed” children, “. . . they are likely to be taken for healthy younger children.”

Are they in fact small but healthy children? Certainly, most of the literature assumes they are not. But without independent evidence of functional impairment the meaning of this kind of “malnutrition” become highly ambiguous. If, on the other hand, they are in fact healthy then one must wonder how they became abnormally small, retaining the appropriate weight to height ratio and their health. Is it genetics? (The incidence of “malnutrition” in the five country study is highest in the two Asian countries.) Or, is something more involved? If so, what?

It is not surprising that medical and nutritional scientists interpret variations in human growth as the result of variations in health and nutrition. But as J. M. Tanner argues,

recent advances in genetics, endocrinology, and other fields involved in the study of growth are creating a fundamentally different view of the process of growth. Tanner recommends that the study of growth become a field of its own, the field of "Auxology", in which health and nutrition contributes a part, but only a part, of the explanation of a far more complex and even sophisticated growth process than has hitherto been contemplated.

The prevailing theory of growth and nutrition may be described as the "Deprivation Theory." Under this theory, it is assumed that every individual is born with a given, genetically determined, potential growth curve. If the individual is healthy and well nourished, he will grow along this curve. *Per contra*, growth significantly below this curve indicates poor health and/or malnutrition. Of course some people are normally small, and it is difficult to determine if any small individual is abnormally small or not. But in large populations a skew of the distribution curve of size toward the small is regarded as evidence of poor health and malnutrition in that population.

In contrast to this view, there is an alternative perspective which may be called the "Homeostatic Theory of Growth". This theory is based on a substantially different genetic interpretation in which the *single* potential growth curve of the older view is replaced by the concept of a broad array of potential growth curves in several anthropometric dimensions - in a word, with the concept of a potential *growth space*. Within the bounds of this potential growth space, the growing child may be rather indifferently mapped through various paths of size and shape in response to nutritional and other sources of information from the environment.

The principal instrument of control in the homeostatic process is control over the *rate* of growth of the child. If nutrient constraints are encountered at a given rate of growth, the rate is slowed to bring nutrient demand into equilibrium with nutrient supply. By

thus regulating the speed of internal, physiological "clocks", short term equilibrium is established and the ultimate size and shape of the adult may be molded to its environment.

Of course, there are bounds to these adaptive possibilities. It is an important mathematical property of homeostatic models that while they maintain stability within bounds of variation, they disintegrate into violently unstable paths when the bounds are transgressed [Sukhatme and Margin].

If the homeostatic theory is correct then the dilemma of "nutritional dwarfs" who are not observably impaired in the range of mild to moderate malnutrition (MMM) is resolved. There are no impairments because this range represents an adaptive response of body size to adverse conditions *in order to avoid these impairments*. I have tested this conjecture on a sample of Indian children who were medically screened and known not to be malnourished or unhealthy and who had a normal medical history (ICMR). Over 90% of the 17 year olds in this healthy sample would be considered malnourished by conventional standards used in nutritional assessment studies — many of them moderately malnourished, and some even severely malnourished. Chen found a high incidence of mortality in Bangladeshi children at the severe level of malnutrition but a normal incidence of mortality (and, probably of morbidity) in the range of MMM. Beaton and Ghassemi could find little if any output in terms of mortality, morbidity and even growth in MMM children in the supplementary feeding programs they surveyed. I believe that the idea that there is a continuous relationship between the various degrees of malnutrition and clinical-functional signs of malnutrition is a statistical illusion generated by the habit of curve fitting over all the levels of malnutrition together. If the regressions were made separately for each level of malnutrition, I believe that it would be found that all the significant relationships would be found in the severe level with no significance at the levels of MMM. This statistical prob-

lem incidentally, is the same as that leading to the illusion that there are significant economies of size in American agriculture [Seckler and Young].

From the basic theoretical framework of homeostatic control of the growth process it is but a short step to a conventional economic model of how the control mechanism might be expected to result in an optimum size of a person given the marginal benefits and costs of size. A study of piecework wage earnings by weight of workers appears to yield the typical "S" shaped production function which, if matched up with a linear food cost function related to weight, would yield an optimum somewhere in the mid-range between the largest and the smallest workers [Gopalan]. This curve has often been interpreted as though it demonstrated that the best size is the largest because total product increases through to the maximum size. This interpretation is valid, as any economist knows, only if the marginal food costs of size are zero. While this condition is perhaps satisfied for rich people who consume for pleasure, it certainly is not in the case of the poor who must consume for nutrition. Thus with the optimality theory showing that it would be desirable to be small under conditions of food scarcity and the homeostatic theory showing that it is in principle possible to be "Small but Healthy", this aspect of the argument is conceptually complete.

Policy Implications

The policy implications of this analysis can be addressed in terms of three distinct "Worlds of Nutrition".

World 1 consists of "properly nourished" people as defined by received anthropometric and nutritional standards.

World 2 consists of people who are not properly nourished but who are also not functionally impaired. The available evidence indicates that these small but healthy people have been able to adapt their size — and, therefore, their consumption require-

ments — to less than standard levels without suffering adverse effects.

World 3 consists of people who have been pushed below the threshold of adaptation. These people are small, undernourished even for their size, and functionally impaired.

Roughly speaking world 2 corresponds to MMM people comprising 80% to 90% of all people not of world 1; with the balance of world 3 people either at the severe level of malnutrition, or in clear and present danger of severe malnutrition. From a policy point of view the crucially important distinction between world 2 and 3 is that needy people in world 2 can, while those in world 3 cannot, work if given the opportunity. I believe that food-for-work programs (FFWP) should be the principal instrument of policy for world 2. These programs should be integrated with clinical programs which provide nutritional and medical care and job training to world 3 people so that they can be enrolled in FFWP when they are in condition to work.

The great advantage of FFWP is that they provide both an effective means of excluding less needy people from the income benefits of food aid and a permanent improvement in the economic environment in which these people must live. Since people must do hard manual work in FFWP only the most needy will enroll. Since FFWP create permanent community assets in the form of roads, schools, hospitals, drinking water, irrigation and the like they lay a basis for sustaining the improvements created by food aid. FFWP also provide a mechanism for eventually liquidating the clinical programs necessary for world 3 people. In my opinion, all other programs, such as school lunch programs and supplemental feeding programs for at risk groups, should be used only as a last resort when there is good reason to believe that the FFWP based program is inadequate.

There are three reasons why I am skeptical of these other programs. First, since they are very inept at excluding the comparatively well off from the program, they divert an enormous amount of resources from the

needy. Second, they are targeted to individuals within households, not to the household itself, and I believe malnutrition is a household problem which can only be solved at that level. With rare exceptions, malnourished individuals come from malnourished households and these households are malnourished because the income earning adults cannot earn an adequate living. Until this basic problem is solved, at risk groups will remain at risk. Third, I believe that supplementary feeding programs designed to get world 2 children up on a high growth curve can harm those children when the program is withdrawn. The process of "disadaptation" [Beaton and Ghassemi] set in motion by these programs can easily make children unfit for the economic environment in which they must spend the rest of their lives. Oddly enough, there appears to be no follow up study of the post-intervention lives of children who have been enrolled in supplemental feeding programs, but I would not be surprised if it were found that such children fared worse in the post-intervention period than their controls.

Lastly, a quantitative point. There are probably no more than 150 million people in world 3. If these people need 500 kcal of additional food per day, or roughly one-sixth kg. of wheat equivalent, they would need about 9 million tons of wheat per year. At current world prices of about \$200 per ton this amount of wheat would cost about two billion dollars. Even doubling this amount for administrative and other costs results in a total sum of 4 billion dollars per annum to eradicate the tragedy of world 3 malnutrition.

It would appear to me obvious that the eradication of world 3 should be the first priority of nutrition policy and that nutritional resources should not be squandered on the problems of world 2, problems which only economic development can solve. But until a better scientific basis is established for defining and locating people properly in these three worlds of nutrition the prevailing chaos of nutritional policy will continue. I can

think of no area of scientific research more desperately needed than this.

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