Epidemiology and Prevention of Severe Protein Malnutrition (Kwashiorkor) in Central America

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Educational efforts must be directed along four lines of attack, say these authors, if increased supplies of protein foods furnished at low cost are to become truly effective in eliminating kwashiorkor.

Increasing numbers of public health personnel are working in countries in which many young children die from the severe form of protein deficiency known in Latin America as Síndrome Pluricarencial de la Infancia and in most other parts of the world as kwashiorkor. It has been realized for several years that this syndrome can usually be treated successfully with skim milk gradually supplemented with other foods until the child is consuming a balanced diet.[1, 2] More recently Brock, et al.,[3] have demonstrated that the signs and symptoms of acute kwashiorkor disappear or improve markedly when treatment is initiated with a suitable mixture of synthetic amino acids alone. Using essentially the same amino acid mixture our preliminary results appear similar.

It thus seems established beyond reasonable doubt that protein deficiency is primarily responsible for the condition known as kwashiorkor. Although deficiencies of other nutrients are also generally present, they vary greatly from one locality to another. The present paper explores the epidemiologic factors associated with the development of severe protein deficiency in children and suggests measures to prevent the syndrome.

The characteristics of kwashiorkor have been recently reviewed in considerable detail.[4–6] The clinical changes include retarded growth and development, apathy and anorexia, edema, lesions of the skin and hair, diarrhea, and anemia. Among the biochemical alterations are the loss of duodenal enzyme activity and lowered blood serum total protein, albumin, alkaline phosphatase, pseudocholinesterase, and amylase. The liver undergoes severe fatty change. The pancreas shows atrophy of the acini with disappearance of the zymogen granules and the intestinal wall is also usually atrophied. All of these changes are reversed by dietary treatment alone unless the condition is so far advanced that death occurs.[1, 4, 7] Bronchopneumonia is a frequent terminal finding.[8] Vitamins are not required for initiation of cure unless a severe specific vitamin deficiency is present as a complication.

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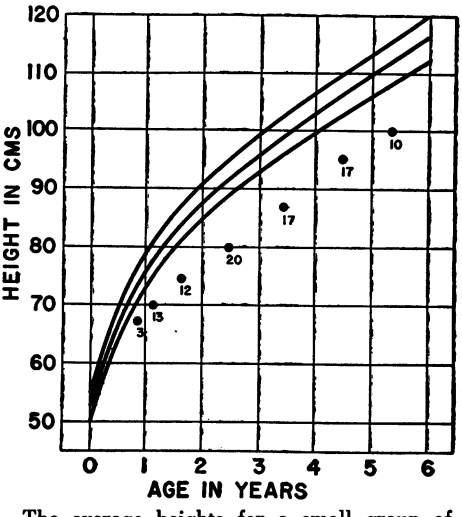
Epidemiologic Factors

In Central America, as in many other parts of the world, the diet of the mother before and during pregnancy and lactation is deficient. Nevertheless, breast feeding is prolonged, often until the next pregnancy or until lactation fails. Only the occasional child who is not adequately breast-fed gets into nutritional difficulty during the first eight to 10 months. When deficiency occurs before the latter part of the first year it is more likely to be due primarily to partial starvation from insufficient milk and to result in marasmus rather than kwashiorkor. For the great majority of children the critical period begins toward the end of the first year after birth, when the amount of milk secreted fails to meet the protein needs of the child. At this time supplementary food may still not be given or, more commonly, consists largely of carbohydrate; as a result, growth and maturation become slowed.

When weaning occurs no special consideration is given to the protein needs of the young child. It is not uncommon to withhold from the child of this age even the small amount of meat or egg consumed by the other members of the family. The child is left to consume "tortillas," starch gruels, some vegetables, and coffee, often in the mistaken belief that these are appropriate foods for children of this age. A child fed in this way shows very poor growth until its competitive position in the family improves, generally by the time he attains school age, if he survives to this point.

The great majority of rural and poor urban children in Central America are found to be markedly retarded in height and weight in comparison with well nourished children of the same age.[9-12] The data show that Central American children tend to follow the growth curves for well nourished individuals until near the end of the first year. Figure 1 is an example of growth data obtained from children in a poor urban district of Guatemala City. In this particular group of children retardation is evident even in the average figures for the first year. Bone maturation is similarly affected; Figure 2 gives an example taken from a survey in the rural Guatemalan village of La Fragua. A study of 1,000 school children attending maternal and child care clinics in all parts of El Salvador demonstrated this same trend.[13]

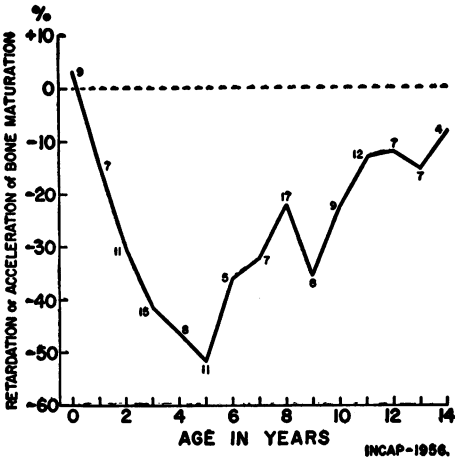
Figure 1



The average heights for a small group of preschool children in a poor district of Guatemala City are compared with INCAP standards for well nourished children. These standards do not differ from those for well nourished children in the United States. These same children show a corresponding retardation in both weight and bone maturation. The number of observations is given adjacent to the corresponding point on the curve. The solid curved lines give the mean ± one standard deviation.

Among the large number of children with underlying protein malnutrition are some who are on the verge of developing kwashiorkor and who show one or more signs of the syndrome. A recent survey in a poor sector of Guatemala City revealed six such persons in a group of approximately 100 children.

Figure 2



The percentage of retardation in bone maturation as compared with the standards of Greulich and Pyle (Radiographic Atlas of Skeletal Development of the Hand and Wrist. Stanford University Press (Calif.) 1950) is shown for a small group of children in the poor rural village of La Fragua, Department of Zacapa, Guatemala. Similar retardation in height and weight was observed. The number of observations is given adjacent to the corresponding point on the curve.

Selected biochemical determinations in these children are compared in Table 1 with those in 53 of the same group without such signs. Each of the six children was low in one or more of the serum constituents which are markedly lowered in kwashiorkor. These represent cases of pre-kwashiorkor or very mild kwashiorkor and are to be found to a greater or lesser degree in any survey of this age group carried out among children in low-income families in Central America.

The degree of atrophy of the parenchymatous organs found in autopsies of kwashiorkor cases provides additional evidence of the prevalence of chronic malnutrition, since this could not occur in the relatively brief time from the onset of the earliest clinical symptoms. Furthermore, the same degree of atrophy is seen in many children from lower economic groups dying from other causes. It should be noted also that the majority of Latin American cases of kwashiorkor, in common with those from a number of other areas, have in addition to protein malnutrition a considerable degree of undernutrition which becomes more apparent when edema disappears. This combination of marasmus and kwashiorkor has been given the name of marasmic kwashiorkor.

Even though obvious signs of malnu-

Table 1—Biochemical Findings in Children with Clinical Signs Suggesting Pre-kwashiorkor in Urban Preschool Children in Guatemala *

Child	Age in Months	Sex	Contents Per 100 ml of Serum: Total Protein gm	Pesudo-cholinesterase pH/hr	Vitamin A mcg	Carotene mcg
1	18	M	4.50	0.61	15.9	19
2	23	M	5.98	0.52	14.0	9
3	29	M	5.48	0.22	1.3	6
4	32	F	6.24	0.71	27.4	21
5	19	M	5.74	0.59	....	7
6	16	M	5.67	0.69	7.0	5
53 other children from the same group			6.73 ± 0.34	1.03 ± 0.22	18.8 ± 8.9	47 ± 25

* The six children for whom individual figures are given were considered to have clinical indications of pre-kwashiorkor. The 53 other children for whom average values are given together with their standard deviations did not have obvious clinical signs of malnutrition other than a marked retardation in growth.

trition other than growth retardation may not be present, children who are basically undernourished are an easier prey to many infections and may die as a direct consequence of pneumonia, measles, whooping cough, infectious diarrhea, tuberculosis, and other such diseases. Furthermore, stress of any kind is likely to be followed by the development of edema, skin lesions, low serum protein, reduced enzyme activity, and the other characteristics of the kwashiorkor syndrome. The stress may be the result of disease or of drastic economic or social changes in the family. Infectious diarrhea, measles, whooping cough, malaria, and acute respiratory infections are examples of the former. The loss of a job, death of a parent, or separation of the family are examples of the latter.

The parasitic infestation, almost universal among lower income groups in Central America, especially in rural areas, has not been shown to enter as an immediate causative or precipitating factor in kwashiorkor. However, the presence of a heavy parasite load undoubtedly contributes to the debilitation of the child. A particularly common precipitating factor in Central America is an episode of infectious or amoebic diarrhea which may be followed by the signs of acute kwashiorkor in as little as two to four weeks.

Recently, rectal swabs were taken from all available children in eight representative Guatemalan villages; depending upon the village, 5–20 per cent were found to be infected with Shigella.[14] INCAP morbidity studies in two of these villages have shown that from 1.3 to 3.6 per cent of the children suffer from clinical diarrhea in the course of any single week. The results of metabolic balance studies showing a marked decrease in protein absorption and retention with clinical diarrhea [15] suggest one mechanism whereby an episode of diarrhea initiates the stress which precipitates clinical kwashiorkor. However, another factor of great importance enters: as soon as the child develops diarrhea the Central American mother usually withholds even the small amount of protein-containing food which the child has been receiving and gives instead gruels which supply mainly carbohydrate. The effects of the diarrhea are often made still worse by the administration of purgatives.

The keeping of accurate vital statistics is greatly complicated by the fact that children suffering from a severe deficiency of protein with a relative adequacy of calories will develop diarrhea as one of the signs of kwashiorkor. As a result, when a child dies with diarrhea and the other signs of kwashiorkor, there is no way of telling whether or not infectious diarrhea was at any time involved; in any case the immediate cause of death should be listed as malnutrition rather than infection. However, in many of the Latin American countries most of the death certification is not done by physicians and the cause of such a death is usually given as "gastroenteritis," "dysentery," "diarrhea," or "parasitism." These stated causes are compiled by the countries and forwarded to the Pan American Sanitary Bureau and World Health Organization which must publish reports on the causes of death in member countries. These reports show "diarrhea and gastroenteritis" to be the leading cause of death in children in many of the Latin American countries. Frequently, malnutrition is not even mentioned as an important cause of death. As a consequence nutrition programs usually do not receive the financial and personnel support which their importance merits.

In an effort to obtain data of value in interpreting the significance of the "gastroenteritis and diarrheal disease," listed as the leading cause of death in children in Guatemala, INCAP has been investigating every child death in a

population of approximately 7,000 persons in four rural towns. They include a small town of mixed Indian and non-Indian population, a predominantly non-Indian village, a relatively wealthy Indian village and a relatively poor one.

During the first nine months there were 279 live births, 17 stillbirths, and three deaths due to congenital abnormalities. There were 90 other deaths in children under five. These do not represent the total number of child deaths in the populations, since some children died in the nearby department hospital or on coastal farms where many of the families migrate for seasonal work. However, it was possible to obtain detailed information on 84 deaths of children under five. Of the 31 deaths with diarrhea, only nine were judged to be due to acute infectious diarrhea while 14 were considered due to frank kwashiorkor and eight to severe malnutrition. In contrast 30 were classified in the municipal register as due either to diarrheal disease or parasitism and none was attributed to malnutrition.

The problem is even more evident when the deaths between one and four years of age are examined, since this is the age in which protein malnutrition is most prevalent. According to the INCAP studies, 21 out of 44 deaths were in children dying with all of the symptoms of kwashiorkor or with one or more signs of severe malnutrition; only seven were attributable primarily to diarrhea of presumably infectious origin. Several of the children dying of respiratory or infectious diseases were also severely malnourished, but the malnutrition was considered a contributing rather than a primary cause. In contrast, 28 were classified in the municipal register as either diarrheal disease or parasitism and none was attributed to malnutrition.

These results appear to represent, far more accurately than any official figures now on record, the importance of malnutrition as a cause of death for preschool children in Central America. From the number of children born and the distribution of deaths by years it would appear that at least 30 per cent of the children in these villages are dying before five years of age. When data are obtained on births and deaths occurring outside the village the final figure will probably be higher. It would appear that for all deaths under five at least a quarter are due to kwashiorkor or other malnutrition. In the one- to four-year age group at least half of the deaths appear to be a direct consequence of malnutrition, and there is little doubt that malnutrition is a major contributing cause of death for many of the rest.

Prevention

Since the primary cause of kwashiorkor is a deficiency of protein adequate to supply the essential amino acids in the amounts and proportions needed, it would seem clear that the only complete and permanent solution lies in improving the feeding of young children in the lower economic groups. Nevertheless, the prevalence and severity of protein malnutrition can almost certainly be reduced by those environmental sanitation measures which actually lower the prevalence of infectious diarrhea in young children. However, such measures, although they may decrease the number of deaths, will not correct the very widespread protein malnutrition which is responsible for the retarded physical development and poor resistance to stress situations which characterize the majority of young children in Central America and other similar areas.

It has been frequently—though incorrectly—stated that kwashiorkor is primarily an economic problem and that little progress can be made toward its eradication without raising the income

level. Surveys in rural areas of Central America have demonstrated many times that, in a poor rural community, greater income does not necessarily result in an improved diet for the young child and, indeed, may not even be reflected in the quality of the adult diet.[16–18] Furthermore, such surveys reveal many cases where the amount of the family income spent on alcohol, consumed primarily by the father, would suffice to provide considerable protein of animal origin for the children. Unpublished INCAP data obtained from surveys directed at the food consumed by the preschool child in low income families show that, due to prejudice and ignorance, meat and eggs are often withheld from the young child even when they are available to the rest of the family. Anthropological observations also confirm this. If the child is receiving these foods of animal origin, they are almost certain to be withdrawn immediately if diarrhea occurs for any reason. It should be noted that it is not surprising for diarrhea to be attributed to worms, since the diarrheal stools frequently have in them numbers of Ascaris. In these circumstances merely withholding purgatives would save many lives.

Even feeding milk constitutes a problem since it is not available to many families, and when given sporadically, it is likely to be discontinued because diarrhea ensues. The reason for this is not always clear, but it is probably due either to the fact that the milk becomes contaminated or because the child is not accustomed to it. The introduction of dry powdered milk has been an important contribution to the feeding of children and, in particular, the efforts of UNICEF to stimulate the production of dry milk for this purpose within underdeveloped countries are becoming increasingly effective. The large-scale distribution of milk powder by UNICEF has also been of value, although the difficulties of administration to this age group have prevented more than a small proportion of needy preschool children from being reached by such supplementary feeding programs. Along with any program of milk distribution must also go education to see that the milk is properly protected, after boiling in the case of fresh milk, or after reconstitution with safe water in the case of milk powder. Persons must also be taught that reconstituted powdered milk can become contaminated and dangerous for children if not properly handled.

In many families educating the mother to give the child the same proportion of animal protein as received by the adults would make a great deal of difference. Education for better food habits, even within existing economic limitations, is certainly a major key to successful prevention. This has been repeatedly demonstrated by the many cases of kwashiorkor in families who could have provided the child with a better diet had they realized its importance and known what foods to purchase. A surprisingly high percentage of the children discharged from the INCAP hospital study following treatment for kwashiorkor are brought back by their parents in excellent nutritional state on subsequent periodic return visits as a result of careful instruction of the parents alone.

Another major key to the situation is, of course, to increase the use, not only of milk, but also of other foods of animal origin which are rich in protein. This requires both education as to the value of these foods for young children and direct efforts by agricultural authorities to increase the supply of available animal protein. Technical knowledge has increased greatly in recent years on the management and feeding of livestock and poultry in tropical and subtropical countries. This knowledge, which can significantly increase the production of animal foods and

lower their cost, has as yet been applied to only a very limited extent.

Measures, such as the control of ecto- and endoparasites, improved management of grasslands, introduction of new grasses, use of silage and other feed conservation methods to maintain dry season production, and the use of complete mineral mixtures that contain all of the essential minor elements can revolutionize the prospects for animal protein production in many underdeveloped areas. Nevertheless, there are many countries in which protein malnutrition is prevalent and where it is not expected that sufficient animal protein will be available at low cost to solve the problem of human protein deficiency, at least in the next few years.

Under these circumstances, a preventive measure which could have very wide application would be the development of an effective mixture of vegetable proteins which could be made widely available at a much lower cost than milk and which could be stored and transported easily. However, the development of vegetable protein mixtures to approach animal proteins in biological value requires great care in the selection of the ingredients and in their processing. The quality of a mixture will depend not only upon the amino acid content of its components, but also on the temperature and other conditions of their preparation. The use of plant materials or processing chemicals that are toxic is another possible danger. The compounding of vegetable protein mixtures for human feeding requires, therefore, a detailed knowledge of the origin and nature of the proposed ingredients, the processing procedure employed, and the effect of storage under various conditions. Before field trials are justified biological assays must be carried out in two or more species of animals and careful tests made in human beings under close medical supervision.

For the past two years work has been in progress to develop a low-cost mixture of high nutritive value based on locally available plant products. While the formula is still in the experimental stage, the following combination has given good results in initial animal feeding trials carried out by SCIDA, Guatemala.*

	Per cent
Dry corn masa	50
Sesame meal	35
Cottonseed oil meal	9
Yeast powder	3
Dehydrated kikuyu meal	3
	100

The meals were specially prepared for human feeding and the composition of the mixture as calculated from the available amino acid data for its components suggests that its protein quality should be relatively good. Although it is intended to be used as food supplement, it will supply the essential nutrients for the human diet except ascorbic acid and calories when fed as the sole protein source.

On the basis of the highly satisfactory results of the animal trials, the mixture has been given to five children in the period of late recovery from kwashiorkor. The initial standard diet therapy in these cases consisted of 3–5 gm of protein per kg per day furnished by milk, to which was gradually added cereal, vegetables, fruit, eggs and meat to give a balanced diet.

Since we have been concerned initially with the adequacy of the protein,

* The SCIDA is the Servicio Cooperativo Interamericano de Agricultura, Guatemala, C. A. In the series of trials in rats which were carried out by Dr. Robert L. Squibb, head of the Animal Husbandry and Nutrition Department, excellent growth was obtained. The formula was not improved by substituting skim milk for part of the corn nor by the addition of lysine. The vegetable protein mixtures also produced satisfactory growth in baby chicks when the higher requirements of the chick for certain dietary essentials were met.

a calcium and a multivitamin supplement has been given to all of the children when they were receiving the vegetable mixture alone, although the analytic values indicate that this should not be necessary except for vitamin C and possibly calcium. The experience with these children can be summarized:

R.E.L., a six-year-old girl was admitted with moderate kwashiorkor and weighed 11.6 kg when her edema was lost. After six weeks of standard diet therapy she was given the vegetable mixture for five days as part of a mixed diet. This was well tolerated so that the amount of mixture was increased to supply all of the protein in her diet for an additional seven days. During this period she suffered an accidental fracture while playing and was returned for 25 days to a diet containing milk which included, however, one serving per day of the mixture. She was discharged in good condition on her 103rd hospital day.

F.A.S., a three-year-old boy was admitted with severe kwashiorkor and weighed 7.1 kg after his edema was lost. Following 12 weeks of standard diet therapy, he was placed on the vegetable mixture as a sole protein source. For 10 days the diet contained 3.6 gm of protein and 125 calories per kilo. After nitrogen balance studies with different levels of milk intake, he was returned to the vegetable mixture for an additional 23 days. His acceptance and growth response during both vegetable protein periods were similar to those with milk. He was discharged in good condition on his 190th hospital day.

T.A., a two-year-old boy was admitted with severe marasmic kwashiorkor and weighed 5.8 kg after his edema was lost. He was placed on vegetable mixture as the sole protein source after 16 weeks of standard diet therapy. During the first 22 days when the diet supplied 2.5 gm of protein and 105 calories per kilo, per day, the child's condition was good, but he failed to gain weight. When the amount of mixture was increased to supply 3.4 gm of protein per kilo and the caloric intake adjusted to 112 per kilo, he gained 570 gm in 19 days. This was further increased to 5.4 gm and 150 calories per kilo and he gained an additional 1,360 gm in 43 days. He has accepted the mixture well at all times and he has grown into a sturdy and healthy appearing child.

I.T., a three and one-half-year-old boy was admitted with severe kwashiorkor and weighed 7.8 kg when his edema was lost. He was placed on the vegetable mixture as a sole protein source after six weeks of standard dietary treatment. At a level of 5.1 gm of protein and 150 calories daily per kilo of body weight, he has accepted the mixture well for 30 days and gained 1,020 gm of weight during this period. He is happy and active and has become sturdy in appearance.

M.T.A., a four-year-old boy was admitted with moderate kwashiorkor and weighed 8.5 kg when his edema was lost. He was placed on the vegetable mixture as the sole protein source after six weeks of hospitalization. At a level of 4.6 gm of protein and 140 calories per kilo of body weight, he has accepted the mixture well for 26 days and gained 1,060 gm of weight during this period. The child now looks well and is very active.

Patients F.A.S. and T.A. have also been placed on five-day periods of nitrogen balance using first milk followed, after a suitable adjustment period, by a trial of the vegetable mixture at the same protein level. Both children showed an equal or slightly better absorption and retention of nitrogen with the vegetable mixture as compared with milk. An anthropologist has also studied the food habits and attitudes in rural villages and concluded that such a mixture should be acceptable for the supplementary and mixed feeding of young children.

Thus far all of the information obtained regarding the nutritive value, acceptability, and practicability of the mixture is favorable. If this continues to be the case and it can be made widely available through commercial and other channels, a mixture of this sort could make an important contribution to the elimination of kwashiorkor in Central America. Impetus would also be given to the development of similar mixtures using locally available products to meet this same problem in other parts of the world.

It should be noted that no matter how successful measures to increase the supply of protein of good quality may

be, effective nutrition education will be required to see that the mother actually gives this protein to the young child. As in so many other aspects of public health, education plays a key role. Educational efforts toward the prevention of kwashiorkor must be directed along the following general lines: first, the need for better feeding practices for the so-called normal young child; second, the discouragement of procedures for the treatment of diarrhea, which serve only to weaken the child and aggravate the disease; and third, the teaching of mothers that milk and other animal proteins and the recommended vegetable protein mixtures must be given to the sick child, if he is to recover from kwashiorkor. To these should be added a fourth, the promotion of those measures which will decrease the prevalence of diarrheal disease in young children. If this is done and increased supplies of animal protein or vegetable protein mixtures of high biological value are made available at a sufficiently low cost, the elimination of kwashiorkor and the underlying protein malnutrition which gives rise to it will follow.

Summary

Nearly all children in rural and poor urban areas of Central America suffer growth retardation and other evidences of protein malnutrition. As a result of deficient diet, frequently with the superimposition of a stress factor, many of these children develop the severe form of protein malnutrition known as kwashiorkor. The stress factors include changes in the economic and social environment of the child, such as the death of a parent, separation of the family, or loss of work of the principal wage-earner; the effects of contagious childhood diseases, such as measles and whooping cough, severe upper-respiratory infections and, particularly common in Central America, infectious diarrhea.

The feeding of animal protein, the distribution of cheap but nutritionally effective combinations of vegetable proteins, and educational measures for improved dietary and sanitary habits are important for prevention. General measures designed to improve environmental sanitation and decrease diarrheal disease and intestinal parasitism will be helpful in reducing the incidence of clinical kwashiorkor, but are not a substitute for improved nutrition.

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