SUMMARY

The appreciable prevalence of malnutrition in the poor areas of the world is a tragic and easily observed phenomenon. This is documented from indices of nutrition in the community such as high rates of infant and childhood morbidity and mortality, the onset of growth retardation even before the fetal period, varying degrees of continued growth retardation after birth, particularly, during the post-weaning period and adolescence, clinical symptoms of nutritional deficiencies and so on.

Malnutrition occurs as a result of complex interactions between factors such as poor supplies, poor choice of the foods available, food taboos practiced during illness, specially for children, substitution of traditional foods by non-foods such as coffee and tea or refined foods of doubtful nutritive value, poor utilization of the foods ingested due to gastro-intestinal disorders including intestinal parasite infestations, aggravated by poor environmental hygiene, high morbidity rates and changes in social structure and family organization resulting in changes in patterns of child rearing and care-taker-child relationship and so on. Thus
malnutrition is the result of the interaction of economic, nutritional, psycho-social, environmental and cultural variables. Although, by and large, the poor mother manages to produce a reasonably healthy baby, malnutrition may begin as early as the prenatal period resulting in low birth weights. Infants with birth weights below 2 kg, form 10-15% of all children born among the poor in this country. However, due to generally efficient lactation performance in poor women, the growth rate of the infant is satisfactory in most cases during the first four to six months of age. But an appreciable proportion, some 10% perhaps on the basis of previous studies in this laboratory, may become growth retarded even during early infancy. At this age the supply of breast milk becomes progressively more inadequate for the growth of the child and no proper supplements are introduced except for some weak tea, coffee, diluted cow milk, small quantities of the family diet and or starchy foods such as sago, tapioca, arrowroot, surplus cooking water from rice, etc. Thus the child becomes increasingly undernourished and malnourished. The situation is aggravated by infections, namely, gastrointestinal or respiratory, which further reduce the
child's intake of food both because of anorexia, and parentally imposed restriction while nutritional requirements are increased as a result of illness. The child who is marginally undernourished or malnourished but is proceeding slowly on the path of development may develop severe malnutrition.

Although poor diets are deficient in several nutrients such as food energy, protein, calcium, Vitamin A and riboflavin, and in addition, to thiamine and iodine in rice-eating and goitre areas respectively, nutrients predominantly involved are food energy and protein. A diet that provides a reasonable supply of both is not likely to be seriously deficient in most other nutrients. Although malnutrition has several ecological correlates, children within the same social group vary greatly in their nutritional status raising the question as to why some children develop severe malnutrition while others escape. The two extreme forms of protein-calorie-malnutrition are marasmus and kwashiorkor but differences either in the etiology of the two or in their long-term prognosis have not remained controversial. The probable course of events observed before either is manifested has been described by many workers in the field of
nutrition. Though generalisations have been made about both, we lack comprehension of the differences between these two forms with regard to dietary, developmental and clinical history, the relative extent to which various parameters influenced by malnutrition are affected in these groups, their response to treatment and their subsequent nutritional status. Of particular interest is the problem of the impact of malnutrition on mental development.

Studies have been carried out in this laboratory on the nutritional status of various groups such as pre-school children, school boys and girls and pregnant and lactating women as well as on the effect of supplementary foods on the growth and development of the former two groups. The studies were further extended to include children showing severe forms of protein-calorie-malnutrition in Trivandrum, Kerala State and a Nutrition Rehabilitation Centre was established in collaboration with the Pediatrics Department of the Medical College, Trivandrum. Data were obtained on the severity of malnutrition, age of onset, retardation in physical and skeletal growth and the psychological status of malnourished children admitted to this centre. Further studies were conducted to observe the growth response of undernourished and malnourished
children to a supplement of tapioca and fish in areas from which the children came for admission to the centre.

The present studies were designed to identify to the extent possible, factors associated with severe malnutrition such as economic status, family size and organization, birth order of the malnourished children, age intervals between the child and his siblings, the environment, the child's pattern of growth and development as well as type of foods introduced at various ages as reported by the mother and foods given during episodes of different types of illness. These studies were carried out to the extent possible on the child admitted to the Nutrition Rehabilitation Centre attached to the Pediatrics Department of the Medical College, Trivandrum with the involvement of the author's laboratory. Kerala was chosen as the venue for these investigations because of the appreciable prevalence of severe malnutrition manifested in the form of both marasmus and kwashiorkor so that comparative studies of the two conditions are possible. The results obtained were compared with those from parallel studies in Madurai at a similar Nutrition Rehabilitation Centre.
attached to the Pediatrics Department of the Medical College, Madurai where the dietary patterns are somewhat different and about 50% of the children admitted with malnutrition show moderate to severe eye lesions resulting from vitamin A deficiency and occasionally culminating in blindness. Comparative data were obtained on children admitted with marasmus, marasmic kwashiorkor and kwashiorkor on aspects such as age and sex distribution of children, their body build as determined by weight and other somatic measurements, presence of clinical symptoms of nutritional deficiency, nutritional status as judged by biochemical criteria, skeletal status and psychological status in addition to the aspects mentioned earlier.

Studies were extended to observe the response of the malnourished children to dietary rehabilitation for 3 to 4 weeks at the Nutrition Rehabilitation Centre and their progress subsequent to discharge as determined by 'follow up' studies to the extent possible. Of the 935 children admitted since 1972 about 353 stayed for 3-4 weeks or more and around 140 stayed for 1-2 weeks. The remainder left soon after admission or within a week because it was not possible for either the mother or a care-taker to stay with the child. A small number had
to be transferred to the pediatric ward for intensive care. In some cases, they left because they felt that the child was receiving only food and not medical treatment. An attempt was also made to study the changes in the pattern and prevalence of malnutrition during the period of study (1972-78). For this purpose, the data are analysed for two periods 1972-1975 and 1975-78 as some of the changes to be described subsequently were clearly evident in the later period. These two periods are characterised as phase I and phase II.

A total of 349 children were studied during 1972-75, and 417 during 1975-78.

The age incidence of the severe forms of malnutrition in relation to the earlier (prior to 1975) and later (after 1975) years of the study period showed an increase in the percentage of children admitted below the age of one year from 6.5% during the earlier period to 11.3% during the latter period, and a decline in the percentage of children who were admitted above the age of 72 months. In studies in Madurai, during the latter period, children below one year of age were still rare.
The children were classified into the three clinical categories, marasmus, marasmic kwashiorkor and kwashiorkor both according to WHO guidelines and on the basis of the severity of edema. According to the former, those with body weights less than 60% of Boston norms but with no edema are classified as marasmus, those with a similar degree of growth retardation and also exhibiting edema as marasmic kwashiorkor and those with body weights more than 60% of Boston norms and manifesting edema as kwashiorkor. The clinical diagnosis of the presence or absence of edema was cross-checked with the extent of weight loss in the initial stages of dietary rehabilitation due to loss of edema water. As the WHO classification sometimes gave anomalous results with regard to kwashiorkor, in that, the post-edema weights were less than 60% of Boston norms, the children were also classified according to the extent of edema present as judged by weight loss on rehabilitation, namely, none or negligible, less than 0.8 kg and more than 0.8 kg. When the two study periods were compared, an increase was found in the percentage of children admitted with marasmus during the latter period and a decrease in that of children admitted with severe edema associated with an increase in the number of children below one year of age as mentioned earlier.
The children admitted were mostly from either coastal or interior areas of the district of Trivandrum with a slightly higher per cent from the former. The general dietary pattern in the families of malnourished children was based on rice, tapioca and fish with coconut chutney, legumes or vegetables in lieu of or in addition to fish occasionally. The proportions of rice and tapioca varied with the percentage of calories derived from tapioca ranging from below 10 to 78. Fish consumption which depends on the availability during different seasons also showed a similar variation. As a result the daily protein intake varied from 8.6g to 73.7g with a mean intake of about 25g per capita per day. The corresponding value for food energy was 1322 kilocalories with a range of 900 to 1944. More than sixty per cent of the families did not include pulses, milk or vegetables except for variety in their diet. The pattern was found to be the same in the families of unselected controls of similar age range drawn from an area where malnutrition is prevalent. No apparent differences in the dietary pattern were found between the families of children in the three clinical categories, except, perhaps, for slightly greater tapioca consumption associated
with the families of 'kwashiorkor' cases.

The average household size of the families of malnourished and control children was found to be similar and did not show much variation from the census report for Trivandrum state.

The occupation of the parents of malnourished and control children showed that a greater proportion of malnourished children hailed from families of daily wage earner group (fishermen and other daily labourers) and unemployed. About thirty per cent of the mothers of malnourished children were daily labourers and had to leave the children in the care of other members in the family. Only three per cent of the mothers worked at or near the home and had access to the child during working hours.

Malnourished and control children did not differ either with regard to birth order, number of siblings, inter-sibling intervals or family size.

On the basis of the mothers' report, a greater proportion of children with marasmus were weaned on to diluted cow milk, weak tea or coffee or thin rice gruel
before the age of six months whereas children with kwashiorkor were continued on breast milk for a longer period. Reasons reported for the termination of breast feeding were a subsequent pregnancy, inadequacy of milk, infant's illness or mother being employed away from home.

The children were usually weaned on to normal diet by the age of one year with no special supplements. The regular use of ragi porridge with palm or cane sugar reported practised in the previous generation was practised occasionally during phase I but seldom during phase II. The foods given during recurrent episodes of diarrhea were sago and/or arrowroot, barley water, rice congee or bun with tea or coffee. During phase I, quite a few had barley water and glucose on the advice of the physician. Those given during fever were coffee or tea without milk, bread, bun or rice congee. In both cases, the dietary changes were such as to aggravate or precipitate malnutrition.

Normal milestones such as holding head steady, sitting up, standing and walking were reported to have been delayed in marasmic children and to a much smaller extent in kwashiorkor children. A higher proportion of marasmic children were weaned earlier and showed chronic
growth retardation of early onset on the basis of the responses of the mother to questions about how big the child was at birth, six months, one year and so on.

Prevalence of intestinal parasite infestation was high in preschool age in general and in malnourished children in particular due to the poor living conditions and improper sanitary facilities in their localities.

The major infestations found were ascariasis (20%) and multiple infestations (30%). The corresponding values for the controls were 40% and 33% respectively.

A number of clinical symptoms were manifested by the malnourished children. These included skin changes (84%), hair changes (72%), eye lesions (13%) and mouth changes (35%). But in spite of the reported association of severe malnutrition with vitamin-A deficiencies, because of defective intake, absorption, transport, storage and retrieval of the vitamin, only mild eye lesions, suggestive of vitamin-A deficiency were found in a very small per cent of the group studied. In contrast, in Madurai, 55% of the malnourished children had eye lesions with 34.5% showing severe eye lesions such as keratomalacia and corneal ulcers with even corneal rupture in a few cases. The differences are perhaps due to differences in vitamin-A stores acquired by children.
prior to the onset of malnutrition and their ability to use these stores in spite of protein deficiency.

As the diet during the prevalence of malnutrition was deficient in food energy, protein and vitamin-A in both regions, growth status of malnourished children as judged by weight or height and psychological status were found to be affected. Growth in stature was not affected to the same degree as that of body weight, but height deficits seemed to increase with age to some extent and is related to prevalence of chronic malnutrition. Per cent deficits in head and chest circumference also showed a similar pattern.

During dietary rehabilitation at the centre the catch up growth was very rapid, the average gain in weight being 578% of expected gains. This pattern showed some variation with age at varying intervals. Children monitored after discharge showed great variation in their continued progress towards normal development with normal or good growth in 25%, moderate growth in 45% and poor growth in 30%. Similar variations were found in psychological status.

Malnourished children showed a much greater degree of skeletal retardation than controls but the three clinical categories did not differ in this regard. They also showed poorer bone mineralisation as judged by measures of cortical thickness.
With regard to serum total protein and albumin levels, malnourished children in the three categories did not show any appreciable differences whereas, in Madurai, clearcut differences were observed between marasmus and the other two conditions. Both these observations have been made by other investigations.

The serum calcium levels of malnourished children were less than in controls but did not show any appreciable differences between the different clinical categories when the two regions were compared, whereas, the serum phosphorus levels tended to be lower for children in Trivandrum, perhaps because of a great prevalence of vitamin-D deficiency in Trivandrum as the children often lived in the midst of dense coconut plantations with limited penetration of sun light and also because of longer rainy seasons. Serum magnesium levels were found to be very low in children studied in Trivandrum than in Madurai and this may be due to poorer intakes of this mineral and its low concentration in drinking water, which is very soft in Trivandrum.

Urinary nitrogen and creatinine excretion showed a significant decrease in malnourished children when compared with controls.
Studies on psychological status using the Cattell scale showed that malnourished children had a low mean IQ score when compared with their siblings who were presumably better nourished, the children from the rural poor and the controls from the urban upper class. It was also observed that children who were admitted at a younger age tended to have higher IQ scores than children of the older age group although the variability was very large perhaps because of prolonged poor development.

Except for the fact that children with extremely severe growth retardation (body weights less than 40%) were found to have lower scores, no association was found between psychological performance and nutritional status.

In conclusion, although it was not possible to identify in a clearcut fashion the features in the home environment contributing to the precipitation of severe malnutrition in some but not in others in the same socio-economic group, some factors such as dietary, developmental and medical history emerge as concomitants although poverty seems to be the major concomitant as similar handicaps are readily overcome in upper class. These studies also high light the fact that biochemical profiles in severe malnutrition and its different
categories may vary in different regions because of ecological factors. The increase in the prevalence of malnutrition in infants is a cause for alarm and can and should be prevented by the promotion of breast feeding and ensuring the availability of satisfactory weaning foods for the poor.