INTRODUCTION
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Protein energy malnutrition (PEM) is an important public health problem among preschool age children in developing countries because of its high prevalence and its relationship with child mortality rates, impaired physical growth and inadequate social and economic development (Shils et al, 1994). There has been a great upsurge of interest in the study of protein energy malnutrition, which includes different clinical syndromes all of which are accompanied by retardation of growth and development and are characterised by pathological and biochemical changes, metabolic alternation, hormonal adjustment and immunological aberrations (Sen, 1980). Geographically, more than 70% of children with PEM live in Asia, 20% in Africa and 4% in Latin America (WHO, 2001). It was estimated that in 1990, one of every three children under the age of 5 year in the developing world or 177 million children were malnourished based on a weight for age lower than two standard deviations below desirable values (UNICEF, 1991). In developing countries, more than 12 million children die each year from the combined effects of malnutrition and infection. Malnourished children have impaired cellular immunity and are particularly sensitive to opportunistic infection (Chevalier et al, 1996).

Malnutrition is a common problem among children in developing countries. National Nutrition Monitoring Bureau (NNMB) reported that only 10% of Indian children were normal (Gomez classification, 1956), while 8.7% were severely malnourished, 68.7% were underweight, 65.1% were stunted and 19.9% were wasted (NNMB, 1990). The National Family Health Survey (NFHS, 1993) report, which covered whole country, showed an overall prevalence of underweight as 53.4% with values for Punjab and
Haryana being 46% and 37% respectively (NFHS, 1993 and Kumar et al, 2000).

Aneja et al (2001) stated that 51% of children below 5 years age were undernourished. For majority of children, growth faltering started at 4-6 months. The National Family Health Survey data also highlighted the critical period of 6 months to 2 years. Data available from various states showed a similar picture. The percentage of malnutrition continued to rise from 6 months to 2 years and thereafter reaches plateaus. Around 50-60% of children were malnourished by the age of 2 year (Aneja et al, 2001).

PEM, the most widespread form of malnutrition, frequently occurs among infant and young children between 1-5 years of age. In India approximately 20% of children under the age of 4 suffer from severe malnutrition while half of all the children suffer from undernutrition due to lack of maternal knowledge (Saito et al, 1997). About 69% of children under the age of 5 suffer from various degrees of malnutrition. Almost one third of children at birth were underweight which caused a higher rate of mortality and morbidity among infants. The most glaring causes of malnutrition were not always poverty but improper weaning (The Sunday Statesman, Kolkata 15th August, 1999). Prolonged breastfeeding impaired growth of infant has been reported by Simondon and Simondon (1998).

Infant mortality in India and Indonesia was about 8 times higher than that in US and Australia. India had cut its child mortality rate from 26 to 11 and Indonesia had cut it from 23 to 13 per hundred between 1960 and 1982 (World Bank, 1984). Gradually they had reduced the infant mortalities to 10%. However, mortality in the age group of 1-4 years was still at least
10 times higher in India and Indonesia than in the United States or Australia. In the developing world, of the estimated 10.4 million deaths among children under 5 years of age, protein-energy malnutrition was associated as a causative factor for 5.1 million or 49% of these deaths (WHO, 1995). In India, infant mortality rate was 60.81 per 1000 live births as reported by UNICEF (2000). Rao et al (2000) reported that the crude estimates of infant and child mortality were 87 per thousand and 70 per thousand, respectively. Infant mortality rates, for instance, vary from 12 per 1000 live births in Kerela to 96 per 1000 live births in Orissa. UNICEF's report on state of the world's children released globally in December 2000, ranked India as number 49 with an under 5-mortality rate of 105 as against 108 recorded in 1997 (UNICEF, 2001).

Nutritional status of a community is largely dependent upon the economic status, food availability, social customs, beliefs, superstitions, religion, cultural and behavioral patterns in the living environment. These are the important sociocultural factors which play a vital role on the ecology of malnutrition reported by Gopaldas et al (1988) and Prekumari and Devdas (1989). Poor socioeconomic status of the family contributes a lot to the development of malnutrition in the developing countries. Many deep-rooted beliefs, customs, practices, superstitions, food taboos and ignorance join hands to cause malnutrition. Infection and disorder such as diarrhea, malaria or measles, may prove major contributory factors in the development of malnutrition, indirectly or directly. Intestinal parasite infestation may either deprive the host of nutrients or lead to malnutrition by reducing appetite, causing diarrhea or by producing absorptive defect (Gupta, 1983; Gemaat et al, 1998). Poor socio-economic background, poor housing condition,
Scheme 1: Hierarchical model of the causes of the PEM
non-availability of latrine, unprotected water source, attack of pertussis, incomplete immunization, prolonged breast feeding and nutritionally inadequate diet were found to be risk factors for PEM (Getaneh et al, 1998).

Multiplicity of causes:

There is a hierarchy of causes of PEM. At every level there are multiple causes. PEM occurs characteristically in children under 5 years whenever the diet is poor in protein and energy. This condition is coupled with low birth weight and the two conditions when combine endanger the survival, hampering the growth and development of infants. Lack of food, infection and psychological deprivation were the common pathways to anorexia (Waterlow, 1993).

Causes of malnutrition have been divided into three categories, viz. immediate, underlying and basic. Immediate causes are inadequate dietary intake and diseases. Underlying causes are not enough food, inadequate care for children and women, poor health services and unhealthy environments. Basic causes are the political, economic and cultural situations. Political causes include instability, poor system of government and centralization of authority. Economic causes are linked to poverty (Kavishe, 1997).

The main causative factors for malnutrition among infants and preschool children in developing countries are i) Economic factor, ii) Psychological factor, iii) Cultural factor, iv) Physiological factor, v) Environmental factor and vi) Population and family size factor.
Immediate Cause: Inadequate dietary intake

Underlying Cause: Not enough food in the home, Inadequate care of woman and children, Poor health service and sanitation

Basic Cause: political, Economic, Cultural factors

Scheme 2: Causes of malnutrition
Economic factor:

Malnutrition was a common finding especially in children of low socioeconomic class (Mazahir et al, 1988). Economic factor was the main cause of malnutrition. Poverty that resulted in low food availability, overcrowding and poor sanitation of living conditions, and improper childcare were the frequent causes of PEM (Shils et al, 1994). Poverty may endanger the infants’ health from the start if mother nutritional status is poor. Poor socioeconomic status of the family as reported by Rao et al (2000) contributed a lot to the development of malnutrition in developing countries.

Psycological factor:

Stimulation and bonding to the mother in the 1\textsuperscript{st} week of life make an essential contribution to the health and growth of the child. Maternal deprivation as a cause of growth failure has been well recognized by MacCarthy (1974). These deprived children were apathetic, with a pale skin and cold extremities, as in anorexia nervosa. Sometimes there was even oedema. The greater risk of maternal mortality and apathy threatened the quality of childcare (Waterlow, 1993).

Cultural factor:

Maternal deprivation as a cause of growth failure has been well recognized even in affluent societies. Poor health, lack of knowledge, the use of unprotected water, lack of milk consumption and lack of personal hygiene were the main factors. According to Thomas (1999), in developed countries medical condition, rather than lack of food, were often the main contributors to malnutrition.
Physiological factor:

Physiological difference in nutritive requirement or ability to metabolize the ingested food is the first of the factors influencing utilization. The period between the state of weaning and the 5th birthday is nutritionally the most vulnerable segment of the human cycle. Rapid growth, loss of passive immunity and as yet undeveloped acquired immunity against infection produce dietary needs more specific and inflexible than at later periods.

Environmental factor:

Infection and disorder such as malaria, diarrhea, measles etc. are proved to be the major contributory factors in the development of malnutrition indirectly or directly. Infection caused malnutrition through a variety of mechanisms. Intestinal parasitic infestation may either deprive the host of nutrients or lead to malnutrition by reducing appetite, causing diarrhea or by producing absorptive defect (Gupta, 1983). Impairment of digestion and absorption made the diet inefficient in fulfilling the requirement of the child and led to malnutrition. Recurrent respiratory infection and intestinal disorder often precipitated the development of kwashiorkor and marasmus in the malnourished child (Swaminathan, 1988).

Population and family size factor:

Increase in birth rate is another cause of malnutrition in developing countries. It has been noted that birth weight and subsequent growth become worse with increasing birth order; the effect is marked in those of lower socioeconomic status. Growth of population has great impact on the food, health and socioeconomic situation of the country. Malnutrition was prevalent among preschool children who were from low-income families, in
crowded living conditions with poor sanitation and were weaned earlier (Chevalier et al 1996).

**Protein Energy Malnutrition:**

Protein energy malnutrition (PEM) refers to a class of clinical condition that may result from varying degrees of protein lack and energy inadequacy. The term PEM was adopted because it was widely agreed that the major limiting factors in the diet of children were energy and protein. Deficiency of protein was usually not primary and isolated; almost always it appeared to be due to poor intake of food as such (Gupta, 1983). PEM is a widespread deficiency disease among children of low socioeconomic group in developing countries including India, South East Asia and Africa. In many areas nearly half of children do not survive till the age of 5 years on account of PEM; those who survive may suffer from impaired growth and perhaps mental retardation. Its severity ranges from weight loss or growth retardation to distinct clinical syndromes. In PEM when growth retardation is severe, functional deficiencies like poor resistance to infection and poor intellectual development may result. Systematic study has related that the concentration of protein in the diet was adequate but inadequacy of energy or food led to PEM (Gopalon et al, 1971). Major syndromes of PEM are kwashiorkor and marasmus and marasmic kwashiorkor (Jelliffe, 1966; Alleyne et al, 1978; Gupta, 2000).

**Kwashiorkor:**

Kwashiorkor is a severe form of protein energy malnutrition. It occurs due to the imbalance between protein and carbohydrates in which the deficiency of protein is more than the energy. The disease is chiefly encountered in infants and in the preschool age group. Occasionally, it may
be seen in infant aged few months. Kwashiorkor occurs in tropical or subtropical areas usually in regions where economic, social and cultural factors combine to make sufficient protein unavailable to the child (Gupta, 1983). The symptoms of kwashiorkor are as follows: psychomotor changes, muscle wasting, oedema, growth retardation, hair changes, skin changes, fatty liver, anemia and vitamin deficiency. Psychomotor changes are evidenced by mental apathy in the form of silent listless inertness, lack of interest in the surroundings. Muscle wasting with retention of some subcutaneous fat is seen. Growth retardation is evidenced by low weight and height. Oedema is seen over the legs, feet and face and perhaps over certain other parts of the body. Hair changes are noticed in the form of hypochromotrichia (light colour and sparseness), change in texture and easy pluckability. Alternate bonds of light and dark coloured have earned the name "flag sign' which signifies periods of inadequate and adequate nutrition over a prolong period (Gupta, 2000).

**Marasmus:**

Nutritional marasmus occurs usually in subject less than 3 years of age. Marasmus occurs when both protein and energy are deficit in the diet. A characteristic feature of the clinical picture is remarkable wasting of both muscles and subcutaneous fat. The face is wizened and shrieveled. In the early stages, the child is irritable, hungry and craves for food. But in the later stages it may become miserable and apathetic refusing to take anything. Oedema is absent but diarrhoea, mineral and vitamin deficiencies, skin changes, growth and height retardation, gross muscle as well as subcutaneous fat wasting are seen (William, 1972; Gupta, 2000).
Marasmickwashiorkor:
The symptoms of both kwashiorkor and marasmus are found in some cases. This condition is known as marasmickwashiorkor. Children with this form have some edema and more body fat than those with marasmus (Gupta, 1983).

During the 19th and early 20th centuries hair was studied mainly in anthropology. Only few workers were found to study on hair in nutritional evaluation. Hair is a diagnostic exoskeleton structure of mammals. Hair analysis is a precise and simple tool in the assessment of protein energy malnutrition that can be included in any nutritional assessment. But later on investigation on the hair has become much popular and significant in various fields. Hair is an obvious tissue for morphological studies in children with PEM. The use of hair for the early recognition of PEM has undergone intensive investigations. The possible use of head hair in the assessment of PEM has been considered several times. Eleven signs that have been listed as indicative of PEM in young children, 4 deal with hair (Jelliffe, 1966). One of the classical signs in PEM is that the hair becomes thin, sparse and easily pulled out (Waterlow, 1993). Two aspects of hair have received attention: the shaft and root. In the shaft, only the diameter has so far shown any potential for diagnostic purposes. A reduced shaft size in Indian children from the Andes had shown to be closely associated with decreased serum albumin concentrations (Bradfield et al, 1968). Sims (1967) observed reduced shaft size in kwashiorkor. The hair root is affected differently in kwashiorkor and marasmus, which might have been anticipated from the well-documented differences in gross appearance in the hair in these two types of PEM. In kwashiorkor the number of growing bulbs (anagens) was significantly less than normal and usually they exhibited severe atrophy. The
mean bulb diameter was approximately 1/3 of normal values. The number of bulbs in the resting (telogen) phase was also increased significantly. In marasmus there was almost a complete lack of bulbs in the growing phase and additionally more broken hair were found in marasmus than in kwashiorkor (Bradfield et al, 1968; Bradfield, 1972). Decreased in hair root diameter was significantly related to the urinary urea/creatinine ratio and increased hair root atrophy was closely associated with changes in the serum amino acid ratio and also with a depressed percentage of weight for height in Guatemalan preschool children (Nammacher et al, 1972). Growth of hair is affected at the early stages in nutritional deficiency and the diameter of hair root related significantly to such measurement as weight for age. There was a significant difference in shaft diameter between the well nourished and the severely malnourished children (Alleyne et al, 1978).

Valuable information has been obtained from the scanning electron microscopic (SEM) examination of diseased hair (Brown et al, 1970; Taylor, 1971; Rook and Dawber, 1982, Kumar et al, 1991). Taylor (1971) and Muto and Yoshiko (1974) observed defects in scale structure and pigmentation of hair. Caputo and Ceccarelli (1969) noticed the presence of familiar structure on cuticle of normal hair and defect in diseased hair. Fernando and co-workers (1980) found canaliculi formation, irregular outline and some times uniform scale structure of 3 months onwards children whose hair was curly and dry. Fernando and Grimalt (1999) also observed canalicular formation, single torsions and cuticular weathering and suggested this variation might have been resulted from environmental exposure.

Kwashiorkor and Marasmus decrease hair growth because they disturb protein synthesis. It is now well known that hair growth is subject to
nutritional influence. The validity of micro morphological hair changes as an index of protein energy malnutrition and disturbances of amino acid metabolism in kwashiorkor and aminoacidopathies has been established by Orfanos and Ruska (1969). The hair changes in kwashiorkor may comprise lighter in colour, loosely attached roots, as shown by sparseness and easy pluckability. Hair becomes dull, dry and very thin. Various changes of colour may be found. In subjects with normally black hair, the changes usually seen in decreasing order of frequency are dark-brown, red-brown, blond and grey (Bradfield, 1972; Levy, 1991). In marasmus abnormalities of the hair may be seen. Light brown and sparse hair may be found (Jelliffe, 1955). The most striking change in the hair roots of children with marasmus was the almost complete absences of bulbs in the anagen (growing) phase (Bradfield et al, 1968). Sim (1967) pointed out that a decrease in hair shaft diameter usually preceded the other symptoms of kwashiorkor and that the tensile strength was also lowered.

Chuang and Emery (1978) made an investigation on the hairs for the determination of environmental pollutants by measuring the concentration of the trace elements. Chromium and vanadium contaminate the air and subsequently are accumulated in the hair as inert substances. In children with PEM hair, copper was found low, but iron and manganese were found higher (Shakur et al, 2000).

It has been found that extensive work has been done on the hair morphology for clinical evaluation but to the best of our knowledge practically no effort has been made on the ultra structural topography and physical properties of hair of preschool children in severe protein energy malnutrition specially in India. Therefore, an attempt has been made to
reveal ultra structural changes on the hair surface and simultaneous changes in physical properties of hair to note the degree of alteration in relation to PEM among preschool children in Kolkata.