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Protein Energy Malnutrition and the Nervous System: the Impact of Socioeconomic Condition, Weaning Practice, Infection and Food Intake, an Experience in Nigeria

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Abstract: Parental socio-economic condition, childhood infection, weaning practices, and childhood intake of food adequate in protein are known to influence the evolution of protein energy malnutrition (PEM) but this is only scantily documented for our setting. To evaluate the impact of these factors on the development of PEM and its neurological sequel in our setting, sixty-seven malnourished children attending our nutritional rehabilitation centre were analyzed for demographics, weaning age, weaning diets, weights and weight-for-age deficits, parental socio-economic conditions, literacy levels and annual per capita income. They were categorized using modified Welcome classification into four classes of PEM. Predominant neurological manifestations included delayed walking skill, hyperreflexia, spinal ataxia and nutritional neuropathies. Their parents were graded into five socio-economic classes according to the Registrar-General's occupational classification. A survey of food items produced by the parents and the proportion utilized for childhood consumption was carried out. The 67 children, 42 females and 25 males aged 3 months to five years, were categorized as marasmus (18%), marasmic kwashiorkor (16%), kwashiorkor (15%), and underweight (51%). Female children out-numbered males in all age groups and were more often severely affected than males. Children suffering from marasmus (mean age =15.4 months) were significantly younger ($p < 0.05$) than cases of kwashiorkor (18.1 months) and marasmic kwashiorkor (23.2 months) and those who were underweight (18 months). The commonest predisposing infection was recurrent diarrhoea (24, 35.8%), followed by intestinal parasitic infestation (10, 14.9%) and measles (8, 11.9%). The Registrar-General's occupational grouping placed most (91.6%) of the fathers and all mothers in the low socio-economic classes. Only meager proportions of parents produced protein rich farm products and utilized them child care. Poor parental socio-economic condition, infections, faulty weaning practices and low intake of protein-rich diet are vital to the development of PEM in our setting.

Key words: Malnutrition, kwashiorkor, marasmus

Introduction

The most common form of malnutrition in Africa is protein energy deficiency affecting over 100 million people; especially 30-50 million children under 5 years of age (Maletnlema, 1992) and almost additional 200 million are at risk (Maletnlema, 1992). Up till now, protein energy malnutrition (PEM), a known sequel of food insufficiency and poor socio-economic conditions (Dulger *et al*., 2002) continues to be a major public health problem and a source of major concern in developing third world countries including Nigeria. Various authors have identified the impact of a number of risk factors underlying PEM. Involvement of the nervous system by PEM is thought to result from not only deficiencies of protein and energy alone but from simultaneous deficiency of micronutrient related to brain growth and development. The aim of this study is to evaluate the pattern of PEM and associated neurological manifestations seen in our setting, and the impact of parental socio-economic conditions, childhood inter-current infections, weaning practices as well as parental production and childhood consumption of certain essential food items on the pathogenesis of PEM.

Materials and Methods

In a retrospective semi-rural-community-based study of children with PEM at Ile-Ife and Ilorin, Nigeria, we analyzed the demographics, weaning age, weaning diets, weights and weight-for-age deficits, family size as well as parental socio-economic conditions, literacy levels and annual per capita income. Employing the modified Welcome classification of PEM, based on weight-for-age (WA) deficits and presence or absence of oedema, the children were categorized into the four clinical syndromes of PEM including kwashiorkor, marasmic-Kwashiorkor, marasmus and underweight.

Their parents were categorized into social classes according to the Registrar-General's occupation classification devised by T.H.C Stevenson, the Chief Medical Officer of the General Registrar's office. Adopting the recommended guidelines for balanced diet for children in Africa we determined the availability of common local foods known to supply adequate nutrition

for healthy living (Food Basket Foundation International, 1997). In order to determine food consumption pattern and the frequency of intake of identified foods (Food Basket Foundation International, 1997) by the children, pre-tested food frequency questionnaires were administered by trained personnel to respondents who were either mothers or care givers of the children participating in the study.

The inter-current infections suffered by the children within three months prior to onset of PEM were extracted from the case files and by interview technique. Data generated were analyzed using standard statistical methods and p-value less than 0.05 was taken as significant.

Results

The 67 children consisted of 42 (62.7%) females and 25 (37.3%) males (sex ratio 1.7:1) aged 3 months to 5 years. PEM was most frequent between 12 and 24 months of life. Approximately half (34, 51%) of the children were categorized as underweight, while others were marasmus (12, 18%) marasmic-kwashiorkor (11, 16%) and kwashiorkor (10, 15%). Their mean weight-for-age deficits were 75.7, 53.4, 60.9 and 70.3% respectively. Marasmic children were generally younger (mean age = 15.4 months) than children with Kwashiorkor (mean = 18.1 months), underweight (mean = 18 months) and marasmic- kwashiorkor (mean = 23.2 months). Clinical features of malnutrition were not significantly different from established norms but the predominant neurological findings included apathy, irritability, delayed walking skill, muscle atrophy (decreased muscle bulk), hypotonia, hyperreflexia, spinal ataxia and nutritional neuropathies, occurring in combinations which varied according to PEM syndromes.

Table 1 shows the inter-current infections suffered within three months prior to the onset of PEM. The commonest infection was recurrent diarrhoea (24, 35.8%), followed by intestinal parasitic infestation (10, 14.9%) and measles (8, 11.9%). Five of the children (7.5%) suffered from multiple infections including respiratory tract infection, malaria and gastroenteritis within this period.

The weaning age varied from 4 months to 2 years with an average of 13.5 months. There was significant difference between lengths of breast-feeding in underweight children and the length in children with overt malnutrition (i.e. marasmus, marasmic - kwashiorkor and kwashiorkor) ($P<0.05$). Approximately, 60% of the children with overt malnutrition were breast-fed for less than 12 months while more than half of children who were underweight had exclusive breast-feeding for more than one year. More than 80% of the children were weaned on a thin gruel made from maize (corn pap or "ogi"), sorghum, or millet, the traditional weaning foods in Nigeria. Often, no milk, groundnut paste, sugar, legumes, oil seed, melon, beans or soybean were added and with the children being force-fed using the right palm with finger closure of both nostrils; a detested practice peculiar to Nigerian mothers.

Thirty four percent of the fathers were farmers married to petty traders, constituting the largest occupational match between parents. Other fathers included drivers (12%), carpenters (10%), bricklayers (7%), schoolteachers (1.7%) and government clerical workers (1.7%). Miscellaneous father's occupational groups included tailors, electrical repairers, automobile mechanics, night watchmen and the clergy. This distribution of occupations placed most of the fathers in the Registrar-General's low social classes III (52.8%) and IV (38.8%) respectively. Aside from petty traders, some women sowed cloths and others were permanent housewives, with all belonging to the low social classes IV (30%) and V (70%) respectively. Over 70 percent of the men and women were illiterates; 22% had primary and post primary (secondary) education, while less than 10% had post-secondary education. The average annual per capita income was N60.000.00 (USD 420) for men and N32.000.00 (USD250) for women. An average of 80% of this income was spent on food. To meet other expenditures such as clothing, medical aid, children school fees and house construction and repairs, loans were taken from cooperative units or community banks at high rates of interest.

Table 3 shows the production rate of common local food items, recognized as protein rich sources and the consumption-frequency of such items by children in the families studied. Less than 5% of the parents produced or had milk and milk products readily available for consumption of their children and very few (22%) agreed to having meat and poultry available but only half of these parents utilize the items exclusively for child consumption. Legumes, oil seeds, cereals and grains and starchy foods are more readily available just as beans, groundnut, oil palm, maize, guinea-corn, cassava and coco-yam, but only 50-60% of these are reserved for family consumption while the rest are old or exported for monetary gains (Table 3). The families interviewed used less than 20% of fruits and vegetables produced for consumption.

Mortality rate was higher (31%) in children with marasmus than those with Kwashiorkor (26%) and marasmic kwashiorkor (23%).

Discussion

The results of this study confirm those of many previous studies, which indicated a strong influence of socio-economic status, infectious diseases and food intake on malnutrition among children in developing countries (Devi Yasoda and Geervani, 1994). As revealed in this study children aged 0 to 3 years are nutritionally the most vulnerable, the vulnerability reaching a peak at between 12 and 36 months of life confirming previous reports. The study has also shown that the sex ratio in PEM and the relative frequency of its

Table 1: Inter-current infections occurring within 3 months prior to onset of protein energy malnutrition (PEM) in 53 of 67 children

Type of infection	K	MK	M	UW	Total
Diarrhoea	6	4	10	4	24
Respiratory tract infection	-	-	-	2	2
Measles	2	2	2	2	8
Intestinal parasites	2	0	0	8	10
Skin sepsis	0	2	0	2	4
Multiple infections	0	3	0	2	5
Total	10	11	12	20	53

K=Kwashiorkor, MK=Marasmic-Kwashiorkor, M=Marasmus, UW=Underweight

Table 2: Weaning age in 67 children with protein energy malnutrition

Age at weaning (months)	PEM SYNDROMES				
	KW	MK	M	UW	TOTAL
-3	0	0	0	0	0
-6	3	4	3	2	12
-9	3	3	4	3	13
-12	2	2	3	3	10
-15	1	2	2	13	18
-18	1	0	0	12	13
>18	0	0	0	1	1
TOTAL	10	11	12	34	67

K=Kwashiorkor, MK=Marasmic-Kwashiorkor, M=Marasmus, UW=Underweight

various syndromes vary with different communities. The female: male ratio in this report was higher than those of Ogbeide *et al.*, 1971 (1.2: 1) in Ibadan, Southwest Nigeria and Meremikwu's series (Meremikwu *et al.*, 1992) (1.5.1) in Calabar, Southeast Nigeria. The reason for a consistent gender preference of PEM in favour of the female sex is not clearly understood. The role of the endocrine system and differences in hormonal milieu cannot be entirely ruled out. Even when overt protein-energy malnutrition alone (i.e. marasmus, marasmic-kwashiorkor and kwashiorkor) is considered, children with marasmus (18%) were second to underweight children, but Kwashiorkor was the commonest syndrome in the other two series (Ogbeide, 1971 and Meremikwu, 1992). In this series, the mean weight for age deficits was least in children suffering from Marasmus as expected. This predisposed them to a higher mortality rate (31%) than children with kwashiorkor (26%) and marasmic kwashiorkor (23%), confirming previous reports (Meremikwu, 1992) in which mortality rates were 60%, 10.4% and 20.8% in children with marasmus, kwashiorkor and marasmic - kwashiorkor respectively.

It has earlier been suggested that the inverse relationship between anthropometrical indicators of malnutrition and mortality is region or population specific (Pelletier, 1995). Currently, however, it has been shown that this risk is constant across diverse world populations including India (Kielmann and McCord, 1978), Bangladesh (Sommer and Leowenstein, 1975), Papua New Guinea (Heywood, 1982) as well as Africa (Briend and Bari, 1989) representing diverse ecological, disease, and cultural environments (Pelletier, 1995). Furthermore, contrary to the widely held view that the effects of malnutrition on mortality are confined to the severely malnourished, this study, in agreement with others (Pelletier, 1995), has shown that mortality amongst the mildly malnourished is higher than what obtains among healthy children of the same age group. Pelletier, 1995 has opined that the association between malnutrition and mortality does not appear to be due simply to the confounding effects of socio-economic factors and inter-current illness or infection. The results of this study suggest that inter-current infections exert a significant impact on the pathogenesis of PEM in the study population, thus corroborating the vicious cycle view of malnutrition and infection held by many authors. Diarrhoea and measles exerted the greatest burden on the development of PEM in our setting. Children with PEM loose their resistance to infections because of a disordered immune system leading to increased inflammatory response due to increase in pro-inflammatory cytokines especially interleukine-6 (Dulger *et al.*, 2002). There is growing evidence that the physiological synergism between malnutrition and infection, which has been recognized for sometime, have multiplicative and not just additive effects on child mortality at population level (Pelletier, 1995).

The development of PEM is fundamentally related to insufficient nutrition (Dulger *et al.*, 2002) no matter what

Table 3: Proportion of parents producing food items and proportion of food items utilized for child care by parents of children with PEM

Food Groups	Foods Items	Nutrient Supplied	(%) Parents producing food item	(%) Food items for family consumption
Milk and Products	Fresh milk, skimmed/ condensed/powdered milk, butter, yoghurt and ice-cream, local cheese-"wara"	Protein, Calcium, vitamin A, Niacin, magnesium, Thiamin riboflavin, Cobalamin.	20	4
Meat, Fish and Poultry	Poultry, fish, snails, eggs shrimps, crabs, other sea products. edible insects (e.g. locusts, crickets)	Carbohydrates, Protein, iron, B complex vitamins	22	11
Legumes and its products	Soybeans, Soybean milk, cowpea, moinmoin, akara balls.	Protein, thiamin, niacin, iron, vitamic C (obtained from sprouting beans).	70	36
Oil seeds and nuts	Melon, groundnut / peanuts, almonds, oil palm, soybeans	Energy, Protein, Iron, Vitamin A, D, E, K	79	30
Cereals and grains	Bread/other wheat products (e.g. semovita, rice, maize, guinea corn, millet	Carbohydrate, B-complex vitamins, Iron, magnesium, protein	93	80
Roots, starchy fruits and tuber	Yam, irish and sweet potatoes, cassava, plantain, breadfruit, cocoyam.	Energy, carbohydrates.	98	50-60
Fruits and Vegetables	**Fruits:** Mangoes, guava, paw-paw, coconut, orange, grapefruit, tangerine, banana, pineapple, avocado pear, water melon. **Vegetables:** Spinach, mushrooms, onions, Okro, bitter leaf, waterleaf, carrots, tomatoes, cabbages and lattice	Water soluble vitamins especially folic and ascorbic acid. Carotene (the precursor of vitamin A) Calcium, Iron, Magnesium, Zinc, Phosphorus	58	19
Fats and Oils	Butter, margarine, vegetable oil	Energy	30	15
Confectioneries	Sugar, jams, jellies, sweets, syrups, beverages drinks, bakery products ice-creams	Energy	10	5

[Adapted after Dietary guide for children in Africa from "Appropriate Technology Dietary Guidelines" Network Nutrition Newsletter, No.2, June, 1997]

the secondary factors are. In this report parental poverty, ignorance and lack of education singly or in combination affected the nutritional status of the children. Most of the food items rich in protein and vitamins were not readily available and when available they were under-utilized for child feeding either because of parental poverty or ignorance of the nutritive value of the items. A greater percentage of these items are sold to meet other family needs. The analysis of food frequency questionnaire indicated that cereals constitute a group of foods most

commonly consumed by the children, while maize meal was eaten in a variety of forms such as corn-pap "ogi' and corn-pap 'eko', both of which are major sources of carbohydrate. The most common weaning diet is corn pap, which is grossly deficient in protein and kwashiorkor and marasmic-kwashiorkor are common in children weaned on this diet. Because of this, efforts have been geared towards improving the nutritive quality of corn pap by the addition of cowpea and groundnut milk (Ojofeitimi *et al*., 2001).

The impact of PEM and predisposing factors on the central and peripheral nervous systems have been long recognized. Early life PEM leads to decreased brain growth (cell number and size), nerve myelination, neurotransmitter production and decreased velocity of nervous conduction. These and other factors may be responsible for neurological changes including delayed milestones of development in the children studied. Delayed walking skill has been reported by Ojofeitimi *et al*., 1984 while Odabas *et al*., 2005 reported auditory brain stem potential abnormalities thought to be due to defects in myelination of auditory brain stem pathways in children with moderate to severe PEM. Muscle weakness, hypotonia and hyperreflexia recorded in our patients are evidences of peripheral nerve and muscle derangements (Chopra and Sharma, 1992) accompanying PEM. Motor and sensory nerve conduction studies exhibit significant abnormalities, which often correlate with the severity of PEM (Chopra and Sharma, 1992). The impact of PEM on the CNS is not determined by the deficiency of protein and energy alone. Simultaneous deficiencies of micronutrient such as iron, iodine, Vitamin A, Vitamin B complex, folic acid, zinc and docosahexacnoic acid have a large role to play. Vitamin A, iron and iodine are among the most important of all the nutrients needed for developing normal learning and cognitive functions, immunity, work capacity and reproductive health (Kapil and Bhavna, 2002). The body cannot synthesize them, so they must be made available through the diet. Their deficiencies are known to have devastating effects on mental health with zinc deficiency causing impaired learning, reduced attention and poor memory (Wasantwisut, 1997). Maturation of the nervous system and consequent behaviour depends in part on pre-natal nutritional factors and postnatal environmental stimulation. In particular, the hypothalamus and the hippocampus are two important central nervous system areas that are vulnerable to such pre and postnatal manipulation (Kehoe *et al*., 2001).

The incidence of PEM and its total impact on child growth and development in Nigeria and in many other African nations are not known. More than half of children in India are unable to grow to their full physical and mental potential owning to malnutrition (Devi and Geervani, 1994). In Nigeria a similar trend observed by Morley since 1974 appears to be unabated yet. Three out of ten children born die due to either malnutrition or a combination of malnutrition and infections, and a further 3 suffer permanent disability. This leaves only four out of ten children to growth to full physical and intellectual status. This trend should not be allowed to thrive any further and preventive strategies require urgent implementation. It is time to provide health facilities and establish child survival projects and policies for preventive interventions.

Issues that need to be addressed should include unsatisfactory food intake and specific micronutrient deficiencies, acute and chronic infections, weaning practices, parental socio-economic status, and poor agricultural practices. Others include lack of knowledge concerning nutritive value of common local foods even when they are available, over-emphasis on cash crops, and lack of food and nutrition policies and management systems.

Conclusion: Poor parental socio-economic condition, infections, faulty weaning practices and low intake of protein-rich diet are vital to the development of PEM in our setting.

References

Briend, A. and A. Bari, 1989. Critical assessment of the use of growth monitoring for identifying high risk children in primary health care programme. Br. Med. J., 289: 1607-1611.

Chopra, J.S. and A. Sharma, 1992. Protein energy malnutrition and the nervous system J. Neurol. Sci., 110: 8-20.

Devi Yasoda, P. and P. Geervani, 1994. Determinants of nutrition status of rural preschool children in Andhra Pradesh, India. Food Nutr. Bull., 15: 335-341.

Dulger, H. M. Arik and M.R. Sekeroglu, 2002. Pro-inflammatory cytokines in Turkish children with protein-energy malnutrition. Mediators Inflamm, 11: 363-365.

Food Basket Foundation International, 1997. Appropriate Technology: Dietary guidelines. NGO Network Nutrition Newsletter. June 1997; No. 2, Pg., 3.

Heywood, P., 1982. The functional significance of malnutrition: growth and prospective risk of death in the highlands of Papua New Guinea. J. Food Nutr., 39: 13-19.

Kapil, U. and A. Bhavna, 2002. Adverse effects of poor micronutrient status during childhood and adolescence. Nutr. Rev., 60 (S Pt 2): S 84-90.

Kehoe, P., K. Mallinson, J. Bronzino and C.M. McCormick, 2001. Effects of prenatal protein malnutrition and neonatal stress on CNS responsiveness. Res. Dev. Brain Res., 132: 23-31.

Kielmann, A.A. and C. McCord, 1978. Weight-for-age as an index of risk of death in children. Lancet, 1: 1247-1250.

Maletnlema, T.N., 1992. Hunger and malnutrition: the determinant of development: the case for Africa and its food and nutrition workers. East Afr. Med. J., 69: 424-427.

Meremikwu, M.M., E.E. Ekanem and A.A. Asindi, 1992. Severe protein energy malnutrition in Calabar, Nigeria: Comparative study of factors affecting outcome of 82 cases. Nig. J. Med., 2: 214-219.

Odabas, D., H. Caksen and S. Sar, 2005. Auditory brainstem potentials in children with protein energy malnutrition. Int. J. Pediat. Otorhinolaryngol, 69: 923-928.

Ogbeide, M.I., 1971. The clinical pattern of protein-calorie malnutrition in Ibadan, Nigeria. WAMJ., 313-319.

Ojofeitimi, E.O., I. Elegbe, M.K. Jinadu and C.A. Oladipo, 1984. Factors affecting delayed walking skill in malnourished children. Child Abuse Negl., 8: 369-372.

Ojofeitimi, E.O., S. Abiose and K.T. Ijadunola, 2001. Modification and improvement of nutritive quality of cornpap "Ogi" with cowpea and groundnut milk. Nutr. Health, 15: 47-53.

Passmore, R. and J.S. Robson, 1970. Demography, vital and health statistics. In: Passmore R, Robinson J.S. (eds) A companion to medical studies. Blackwell Scientific Publications. Oxford. 2nd ed., 2: 34-5.

Pelletier, D.L., 1995. Potentiating effects of malnutrition on child mortality: Epidemiological evidence and policy implications. Food Nutr. Bull., 16: 206-213.

Sommer, A. and M.S. Leowenstein, 1975. Nutritional status and mortality; a prospective validation of the QUAC stick. Am. J. Clin. Nutr., 28: 287-292.

Wasantwisut, E., 1997. Nutrition and development: other micronutrient' effect on growth and cognition. Southeast Asian J. Trop. Med. Public Health, 28 Suppl., 2: 78-82.