Protein-energy malnutrition (PEM) results from prolonged deprivation of essential amino acids and total nitrogen and/or energy substrates. Dietary energy and protein deficiencies usually occur together, but sometimes one predominates the other and, if severe enough, may lead to the clinical syndrome of kwashiorkor (predominant protein deficiency) or marasmus (mainly energy deficiency).

The origin of PEM can be primary, when it is the result of inadequate food intake, or secondary, when it is the result of other diseases that lead to low-food ingestion, inadequate nutrient absorption or utilization, increased nutritional requirements and/or increased nutrient losses. The World Health Organization (WHO) (1) estimates that approximately 300 million children have growth retardation related to malnutrition. In many developing countries 20–75% of all children under five years of age have suffered from PEM (2).

Protein-energy malnutrition, especially among young children, remains one of the principal health problems in the developing countries, including Nigeria. It is estimated that 40% of the children in Nigeria who die under the age of five years were severely malnourished (3). The causes of PEM are multifactorial though it is fairly well established that social and economic factors are the most important determinants in its etiology (4). Other conditioning factors include lack of education, infectious disease, low-food availability and poor feeding habits. This review covers (a) the prevalence of PEM and causes of death in malnourished Nigerian children and (b) the hematological parameters of malnourished Nigerian children.

Prevalence of PEM and causes of death in Nigerian children
A recent report shows that PEM is still prevalent in Nigeria (5). Twenty percent of children under five years of age seen at the Jos University Teaching Hospital were reported to be severely malnourished; the number of malnourished children was also as high as 48% in Zaria, and the incidence of malnutrition is widespread throughout Nigeria (5,6). Various diseases may contribute to PEM. It has been reported that all malnourished children usually have one form of infection or another preceding or associated with malnutrition. The most common diseases associated with PEM include measles, malaria, diarrhea and bronchopneumonia (7,8). These diseases reinforce the well-known interaction between infection and malnutrition. Among viral infections, measles is often the most serious one and the most important cause of kwashiorkor. Aikhionbare et al. (9) found that death due to measles complications was 224% (74 deaths) closely followed by PEM, 23% (70 deaths), and respiratory tract infection was responsible for 18% (55 deaths). The age distribution of death over the study period was 1–12 months (35.2%) and 13–24 months (32%). Diarrhea often accompanies measles, and restricted diet during treatment for diarrhea may give rise to the mortality of malnourished children. Bacterial infections of the intestinal tract and reduced digestive enzyme are associated with malabsorption of nitrogen and increased urinary loss of nitrogen with anorexia. It also has been observed that the ability of kwashiorkor children to dispose of environmental mycotoxins, such as aflatoxins, is impaired (10). Buchanan et al. (11)

### Table 1
Supplementary feeds used by mothers of malnourished children in Nigeria (Ref. 7)

<table>
<thead>
<tr>
<th>Supplements</th>
<th>Malnourished (n=400)</th>
<th>Well-nourished (n=500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pap only</td>
<td>251 (62.8)</td>
<td>60 (12.0)</td>
</tr>
<tr>
<td>Pap + milk</td>
<td>110 (27.5)</td>
<td>224 (44.8)</td>
</tr>
<tr>
<td>Commercial cereal</td>
<td>15 (3.8)</td>
<td>36 (7.2)</td>
</tr>
<tr>
<td>Commercial cereal + milk</td>
<td>17 (3.0)</td>
<td>147 (29.4)</td>
</tr>
<tr>
<td>Solids + milk</td>
<td>7 (1.7)</td>
<td>33 (6.6)</td>
</tr>
<tr>
<td>Total</td>
<td>400 (100.0)</td>
<td>500 (100.0)</td>
</tr>
</tbody>
</table>

*Pap = a maize gruel
Parentheses indicate percentages; *P < 0.001

### Table 2
Composition of some traditional Nigerian weaning foods

<table>
<thead>
<tr>
<th>Food</th>
<th>Water (%)</th>
<th>Energy (kcal/kg)</th>
<th>Proteina (g%)</th>
<th>Carbohydratea (g%)</th>
<th>Fatc (g%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eko (maizepap)</td>
<td>92.8</td>
<td>290.0</td>
<td>6.7</td>
<td>92.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Eba (cassava)</td>
<td>76.5</td>
<td>94.0</td>
<td>1.0</td>
<td>98.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Amala (yam flour)</td>
<td>68.2</td>
<td>270.0</td>
<td>11.4</td>
<td>94.3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

*Dry matter
also found that the hepatic microsomal oxidation and glucuronidation was depressed in acute kwashiorkor, but in due course, on rehabilitation, normal activities were observed.

Ezedinachi and Chucks-Ejezie (12) compared mortalities due to malaria and those due to marasmic kwashiorkor. The total number of children who died from PEM was significantly higher than those who died due to malaria. Malaria caused 42 deaths (3% of all the deaths occurring in the hospital during the study period), while malnutrition was responsible for 174 deaths or 12.5% of the deaths. The most vulnerable age was 2–3 years, of which 33.3% died of malaria and 40.8% died of PEM. The contribution of large family size to malnutrition in the face of scarce resources has been well documented. In the Ighogboja study (7), family sizes correlated highly with childhood mortality, and poor utilization of health facilities also contributed to childhood mortality. Mortality pattern among Nigerian children appears to have increased over the years. In the past, the mortality rate among Nigerian children was not as high as it is today: 14% mortality rate among children was reported in Ibadan (13), 12% in Enugu (14), 11.6% in Ilorin (15), 4.5% in Benin-city (16) and 8% in Calabar (17). Current studies have revealed a much higher percentage of mortality rate of over 40% in most of the Nigerian cities. These findings were based only on those children who were taken to the hospital. Data on the number of children who were not taken to the hospital and who died at home is lacking; therefore, the mortality rate of Nigerian children is much higher than what has been reported. The mortality rate of Nigerian children, including those who died at home, needs to be investigated. In the past, malnutrition was a problem of the “displaced” child from the age of two years, but it is now assuming a disturbing dimension even in the first year of life. This suggests that breastfeeding is not being practiced sufficiently. This fact, combined with the economic recession Nigeria is experiencing, is believed to cause high mortality in children.

**Effect of parent’s income on PEM**

Poverty often accompanies PEM due to low-food availability and lack of means to produce or buy foods. Asokumar and Enahoro (5) and Ighogboja (7) reported an increase in the number of malnourished children among parents who earned less than 400 Niara per month. Parents with higher incomes of about 900 Niara per month had well-nourished children. A family’s food-buying capability may be low due to low income, but the nursing mother’s cultural food practices do determine the types of foods the growing infants eat. Knowledge of local cultural food practices is very important in the search for a permanent solution to the problems of PEM.

**Feeding patterns and composition of traditional Nigerian foods**

Several studies have shown that breastfeeding is still universally practiced throughout Nigeria (18,19). The breastfeeding patterns are reported to be similar in mothers of both malnourished and nourished children. It was reported that on the average over 70% of mothers breastfed their infants for 12–24 months (8). Recent studies, however, have shown that the duration of breastfeeding has been reduced significantly in both rural and urban areas, with commercial milk formula being introduced as early as one month of age (18,19). The drastic change in the pattern of breastfeeding is because of the nursing mother’s need for gainful employment to augment the family’s income. Discontinuation of breastfeeding before the age of six months was shown to have contributed significantly to malnutrition (7). Studies have reported that commercial formulas prepared by these mothers were contaminated by bacteria and also were found to be overdiluted and low in calorie and nutrient density (20,21). Supplementary feeding with semisolids usually starts between two and six months of age. In some cases supplementary foods used by the mothers of the malnourished children included maize gruel (pap) with salt or sugar added to taste (as shown in Table 1) (7). In Nigeria, the major weaning foods are made from corn, millet or sorghum, often in the form of a thin gruel (8,18,22). The composition of these paps have been reported and is shown in Table 2, the protein and energy composition of such paps (“ogi”) is reported to be as low as 1% protein and 30 kcal/100 mL while the water content is as high as 90% (23). Other foods, such as boiled mashed yam, yam flour (“amala”), and cassava meal (“eba”), which are given to older children, are also starchy foods of low-nutritive value. Fortification of complementary foods to increase the energy and nutrient density can be achieved through the use of palm oil, sugar and legumes (cowpeas and soybeans, peanut and melon). The most commonly used complementary foods in Nigeria are cowpeas and soybeans. Both legumes have the advantage of high nutrient content and fulfill the criteria of an ideal complementary food. A combination of soybeans with maize pap “soyogi” was found to be valuable in the management of malnutrition (20,21). The comparison of soybean and egg protein is shown in Table 3. Soybeans are high in energy, fat and protein content. Soybeans are a rich source of vitamins and minerals while their essential amino acids content compares well with that of eggs, and soy protein is less expensive than animal protein. Soybeans initially were not accepted in Nigeria due to their foreign origin. The realization of soy protein’s nutritional value has increased tremendously during the past ten years, especially after it was
found that soybeans could be grown in most parts of the country. Soybeans can be used as a staple food, mixed in variable proportions with almost every Nigerian diet. A combination of soybeans and maize in a 1-to-3 ratio “soyogi” was developed as a weaning food in 1970 (25), and it has achieved wide acceptance in the country.

**Education status of malnourished children’s parents**

Lack of education has been shown to be one of the contributing factors to PEM. Ighogboja (7) and Asokumar and Enahoro (5) reported that about 64 and 72%, respectively, of malnourished children’s mothers did not have formal education. The literacy status of the fathers of well-nourished children was significantly higher than that of fathers of the malnourished children. Both studies showed a decrease in the incidence of PEM as the level of education of the mothers increased. When parents became actively involved in the rehabilitation process of their children, the recovery rate of the children of both illiterate and literate mothers was comparable. Evidence from the literature implicates the educational level of the mothers as major determinant of child survival, regardless of the family’s socio-economic status. Female literacy levels correlate inversely with infant mortality rate, which is very high in countries with low literacy rate for females (26).

Nutrition education in the Nigerian medical school is still at a rudimentary level, and consequently there is little awareness of the nutritional problems of hospitalized patients among the medical professionals. In Nigeria the number and fields of health professionals are far fewer than the number in developed countries; therefore, physicians and nurses are heavily relied upon by the average homemaker for accurate health information. Physicians probably are the main source for nutrition information and thus play a key role in the feeding of Nigerian families. This has been found to be true also in the United States where specialists in nutrition are available in larger numbers than in Nigeria. Nnakwe and Kies (27) reported that none of the Nigerian physicians surveyed received any nutrition education in medical school. This was also true of nurses in the nursing school. The younger nurses reported having had some form of nutrition education. In the same study both the nurses and physicians were not confident of their knowledge of nutrition, and both agreed strongly that nutrition is an important factor in the treatment of illness.

**Hematological parameters of PEM children**

A reduction in hemoglobin concentration and red blood cell (RBC) mass often accompanies severe PEM (28). Dietary protein is essential for the proper production of hemoglobin and RBC mass. Because of the reduction in cell mass and thus oxygen requirements with PEM, fewer RBC are required to oxygenate the tissue. Since blood volume remains the same, this reduced number of RBC can look like an iron-deficiency anemia with a low hemoglobin. Iron-deficiency anemia has been reported in children suffering from PEM (29). Marginal deficiencies of several nutrients, including iron, coexist in the majority of the children (30). Although many nutrients and cofactors are involved in the maintenance of normal hemoglobin synthesis and maintenance of adequate iron storage, the most common causes of nutritional anemia are severe PEM and insufficient intake of iron-containing foods (31). The anemia of PEM may be complicated by deficiencies of iron and other nutrients and by associated infections, parasitic infestation, and malabsorption. A diet lacking in protein is usually deficient in iron, folic acid and, less frequently, vitamin B-12 (32). A greater proportion of economically available food in Nigeria is high in calories and low in iron content (33). This presents limitation in their use to elevate iron status in anemic PEM children. Odeleye and Odeleye (34) studied the effect of high-caloric supplement on the hematological response of some indicators of anemia in PEM children. Results showed that packed cell volume, as well as serum iron and serum ferritin concentrations, increased significantly. A significant decrease in total iron-binding capacity also was reported. A slight increase in hemoglobin and a decrease in urinary iron excretion also were reported but were not statistically significant. Reasons for increases in these indices of iron retention and erythropoiesis following glucose supplementation are unknown. Previous studies suggest that glucose and fructose may indirectly increase mineral absorption in the intestinal lumen by their homeostatic effects on the intestinal mucosa (35,36). However, the mechanism whereby dietary glucose increases iron retention and erythropoiesis has not yet been established. Serum transferrin concentration predicts prognosis for recovery from PEM (37). Serum transferrin concentration correlates highly with nutritional status and sensitively reflects recent changes in nutritional status (38). Very low serum trans-

![Table 3](Ref. 25)

<table>
<thead>
<tr>
<th>Essential amino acid</th>
<th>Soy flour</th>
<th>Egg protein</th>
<th>Soy as % of egg protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>161</td>
<td>125</td>
<td>128.8</td>
</tr>
<tr>
<td>Total sulfur amino acids</td>
<td>74</td>
<td>107</td>
<td>69.2</td>
</tr>
<tr>
<td>Methionine sulfur amino acid</td>
<td>37</td>
<td>61</td>
<td>66.6</td>
</tr>
<tr>
<td>Cystine sulfur amino acid</td>
<td>37</td>
<td>46</td>
<td>80.4</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>30</td>
<td>31</td>
<td>96.8</td>
</tr>
<tr>
<td>Threonine</td>
<td>101</td>
<td>99</td>
<td>102.0</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>119</td>
<td>129</td>
<td>92.3</td>
</tr>
<tr>
<td>Leucine</td>
<td>181</td>
<td>172</td>
<td>105.2</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>167</td>
<td>114</td>
<td>102.6</td>
</tr>
<tr>
<td>Valine</td>
<td>126</td>
<td>141</td>
<td>89.4</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>91</td>
<td>81</td>
<td>112.3</td>
</tr>
<tr>
<td>Protein score</td>
<td>68</td>
<td>100</td>
<td>68.0</td>
</tr>
</tbody>
</table>

**Table 3**

Comparison of amino acid pattern (mg/g total essential amino acid) in soy flour and hen’s egg (Ref. 25)
ferrin levels have been reported in Nigerian children suffering from PEM (37,39). Ifeyironwa et al. (40) used a mostly plant protein-based diet plus iron supplement instead of the milk-based rehabilitation diets for PEM. The PEM children fed plant protein-based diets needed longer periods of nutritional rehabilitation in the hospital than the children fed milk-based diets. And maternal diets needed longer periods of nutrition. From available evidence, it seems that early iron supplementation during the management of PEM is contraindicated. And high levels of free-circulating iron may result in vasoconstriction and possibly increase the mortality of PEM children.

Protein-energy malnutrition is still prevalent in Nigeria. Lack of formal education of the mothers, poverty, a decline in breastfeeding and early introduction of undiluted and often contaminated commercial milk products were some of the contributing factors to PEM. The use of weaning foods that are low in energy and nutrients and the high prevalence of infectious diseases also contributed to PEM in Nigerian children. A combination of soybeans with maize pap "soyogi" was found to seem to be valuable in the management of PEM. The use of weaning foods that are low in energy and nutrients and the high prevalence of infectious diseases also contributed to PEM in Nigerian children.

References