

Malnutrition in developing countries

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Abstract

Although uncommon in industrialized countries, malnutrition in children remains a scourge in many developing countries. It was estimated that, in 2012, 26% of the world's children were stunted and almost 3% were severely wasted. Forty-five percent of all deaths in children aged under 5 years were attributable to the simple fact that they were underweight. Malnutrition occurs most commonly in Southern Asia and sub Saharan Africa. The effective management of severe acute malnutrition (SAM) is a huge challenge in low resource healthcare settings. More effective prevention and treatment of malnutrition is needed urgently.

Keywords kwashiorkor; malnutrition; nutrition disorder; wasting

Nutrition disorders: a leading cause of ill health in the world today

Millennium Developmental Goal 4 aims for a global reduction in under five mortality of two thirds between 1990 and 2015 and a remarkable 50% reduction has been achieved so far. However, most of the estimated 6.3 million deaths in under fives in 2013 were preventable. Under five mortality remains high in sub Saharan Africa (92/1000 live births) and Southern Asia (55/1000 live births), compared with developed countries (6/1000 live births). Outside the neonatal period, the most common primary causes of death are pneumonia and diarrhoea (Figure 1). However, researchers estimate that in 2011, 45% of all deaths were attributable to underlying undernutrition, including growth restriction in-utero, wasting, stunting, micronutrient deficiencies and suboptimum breastfeeding. As a result, significant further reductions in under five mortality will only be achieved with improved prevention and management of malnutrition.

The inner circle represents the 45% of all under five deaths attributable to undernutrition.

Other group 1 conditions are communicable, maternal, perinatal and nutritional causes.

However, the problem is not a simple one. The 21st century has thrown up some paradoxes in nutritional health. Alongside undernutrition we have seen childhood obesity double globally from 1990 to 2011 with alarming increases in developing as well as developed countries. It was estimated that, in 2011, obesity occurred in 7% of under fives globally, with 7% in Africa, 5% in Asia and 15% in developed countries. Current WHO policy to

prevent a further increase in childhood obesity also includes developing countries.

The co-existence of underweight and overweight in the same communities, even in the same households, has been termed a “double burden” of disease. Survey data from Egypt (2006–2010) revealed a 12.6% prevalence of underweight in adolescents (average age 13.2 years), while overweight prevalence was as high as 31.4%. The expression “triple burden” adds micronutrient deficiencies which occur both in underweight and overweight children and is referred to as “hidden hunger”. Obesity and its long term adverse outcomes are discussed elsewhere in this journal. This article focuses on undernutrition. Stunting is addressed under the heading “prevention”.

Definitions and diagnosis

Anthropometry refers to measurement of body size and proportions. Most countries have endorsed the WHO 2006 child growth standards. Anthropometric indices compare a child's size to mean values using standard deviations or “Z-scores” (Table 1). In the resource limited settings where malnutrition is common, accurate measurement of weight and height may be a challenge. Mid-upper arm circumference (MUAC) is easier to measure and interpret. MUAC is similar in boys and girls and is relatively constant from 6 months to 5 years avoiding the requirement to calculate exact age. WHO recommends MUAC as a screening tool for severe acute malnutrition (SAM) in the community. SAM is diagnosed in children with severe wasting and/or nutritional oedema (pitting oedema of both feet) with no identifiable cause such as nephrotic syndrome.

All degrees of undernutrition impact negatively on health and the Integrated Management of Childhood Illness requires healthcare workers to assess the nutritional status of every attending child. Although the risk of death is greatest in SAM (odds ratio 9.4 compared to non-malnourished children), because of the large numbers affected, most malnutrition-associated deaths occur in children with mild and moderate malnutrition. Failure to identify undernutrition misses an opportunity to prevent long-term morbidity impacting on quality of life, development, educational achievement and economic prospects in adult life.

Epidemiology

Malnutrition remains prevalent in under fives in resource-poor countries. In 2013, 51 million children had at least moderate wasting (global prevalence of almost 8%) and 17 million were severely wasted (global prevalence almost 3%) with the highest prevalence in Asia (71%) and Africa (28%). Over a quarter of the world's under fives (161 million) were stunted, with highest prevalences in Southern Asia (56%) and Africa (36%).

Clinical presentation

There are two well recognized clinical syndromes of SAM: marasmus and kwashiorkor. Children with marasmus (Figure 2) have visible severe wasting with an “old man” face, emaciated limbs, clearly visible ribs, buttock wasting, minimal adipose tissue and are often irritable. They may exhibit clinical signs of micronutrient deficiencies, skin and hair changes and infection.

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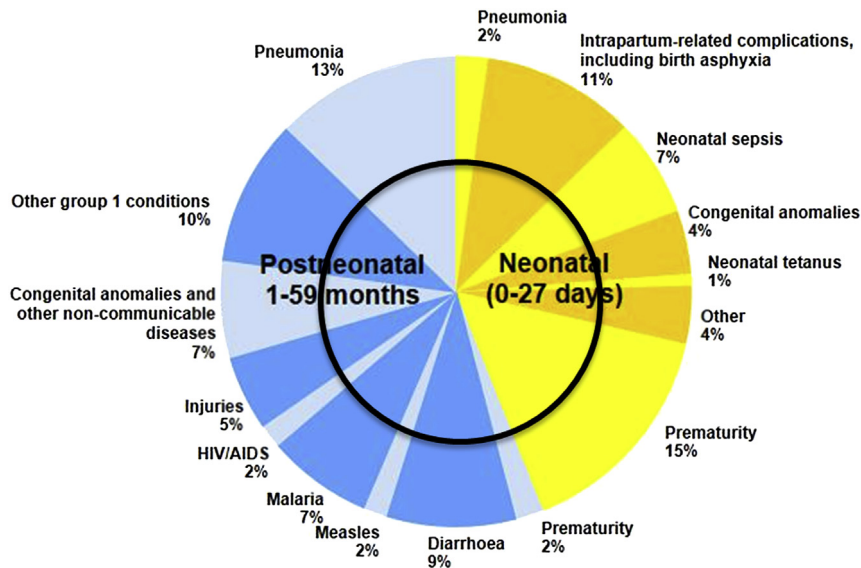


Figure 1 Global cause specific mortality in children under 5 years (adapted from Global Health Observatory http://www.who.int/gho/child_health/mortality/causes/en/).

Children with kwashiorkor (Figure 3), from the Ghanaian Kwa language meaning “the deposed child”, present with oedema and may show other classical features including ‘flaky paint’ dermatitis with areas of hypo- and hyper-pigmentation, sparse depigmented hair and hepatomegaly; these children are typically described as apathetic. Children often present with clinical features of both syndromes: “marasmic kwashiorkor”. MUAC is a more reliable index of wasting than weight for height in children with nutritional oedema.

Aetiology and pathophysiology

Malnutrition results from a combination of inadequate diet and infections which exacerbate energy and nutrient losses through anorexia, vomiting and diarrhoea. Wasting is a consequence of acute malnutrition whereas stunting results from longer-term adversity. Even in the absence of overt infection, microbial contamination of the gut can result in an environmental enteropathy that impairs digestion and nutrient uptake and may result in sepsis from bacterial translocation across the intestinal mucosa.

Although nutritional oedema of kwashiorkor was first described in the 1930s, the underlying pathological mechanism is still not fully understood. Similarity in the diet amongst children with marasmus and kwashiorkor, and animal studies of protein restriction, do not support the long-held assumption that oedema

is a consequence of low plasma protein concentrations resulting from dietary protein deficiency. An alternative hypothesis that increased free radical exposure results in oedema through increased vascular permeability was not supported by the lack of effect of antioxidant dietary supplementation. Recent research raises the possibility of an inherited underexpression of heparin sulphate proteoglycan, a glycosaminoglycan which has a role in mucosal integrity, free fatty acid uptake and keratinocyte adhesion.

“Reductive adaptation”, a response to malnutrition, describes the down regulation of the basal metabolic rate and catabolism of reserves of carbohydrate, protein and fat. One clinically important effect is a decrease in the number and function of Na–K pumps in cell membranes resulting in higher intracellular sodium and loss of potassium into the extracellular space and thence into the urine. The net effects are an increase in total body sodium, low plasma sodium and a depletion in total body potassium. Physiological processes such as heart rate, physical activity and growth are minimized, and the function of all the major organs is impaired. The kidneys are less able to excrete the extra sodium. Cardiac muscle atrophies and hypokalaemia contributes to poor contractility and reduced cardiac function. Hepatic glucose stores are depleted and gluconeogenesis impaired. In addition to environmental enteropathy, digestion and nutrient absorption is impaired by reduced production of acid and enzymes and

Agreed definitions for underweight, wasting & stunting based on anthropometric indices

Classification	Index used	Moderate	Severe
Underweight	Weight for age	<–2 Z-scores	<–3 Z-scores
Wasting	Weight for length/height	<–2 Z-scores	<–3 Z-scores
	Mid upper arm circumference (6–59 months)	<125 mm	<115 mm
Stunting	Length/Height for age	<–2 Z-scores	<–3 Z-scores

Table 1



Figure 2 Child with marasmus (marked wasting, prominent ribs, increased axillary skin folds, 'old man' face).

decreased gut motility. The immune and inflammatory systems are suppressed with weakened responses to infection or injury. SAM management that fails to consider these complex metabolic and physiological changes results in severe or fatal complications.

Clinical evaluation

History

Critical elements are shown in [Box 1](#). A thorough dietary history might elicit inappropriate feeding practices such as supplementation of breast milk with water, untimely weaning and withholding feeds during diarrhoea. Try to overcome language and



Figure 3 Child with kwashiorkor (lower limb oedema, sparse depigmented hair, "flaky paint" dermatitis with areas of hypo- and hyper-pigmentation, angular stomatitis).

History in SAM

History of presenting complaint	Recent weight change/swelling of feet Diarrhoea (duration, frequency, consistency; presence of blood) Fever
Past medical history	Cough; if >2 weeks suspect TB Pregnancy and neonatal history: prematurity, low birthweight, birth asphyxia with feeding difficulty Significant illnesses Contact with TB/measles Known/suspected HIV
Drug history	Regular medications (including traditional/herbal) Immunizations and routine vitamin A supplementation
Feeding and dietary history	Current diet (number of meals/snacks per day, type of food, protein sources, communal serving of food or designated portion) and feeding practices Duration of exclusive/supplementary breastfeeding, use of infant formula/non-human milk, age and diet at weaning
Family history	TB (cough for >2 weeks in the same household) HIV Social history: family structure (number of parents/carers and siblings, birth order, polygamy), maternal mental health (depression), economic status (parental/carer occupation, household income, food availability) Accommodation (crowding, water source, sanitation)

Box 1

cultural barriers and time constraints to obtain a detailed history including assessing the mother's ability to provide nutritional and developmental care.

Examination

As well as searching for the specific signs of malnutrition and micronutrient deficiencies, a thorough examination is required to detect co-morbidities and major organ diseases (e.g. renal disease, congenital cardiac defects, malignancies) that could predispose to malnutrition (see [Box 2](#)).

Accurately assessing the hydration status in SAM is notoriously difficult: mucous membranes appear dry due to atrophied salivary and lacrimal glands, and skin turgor appears decreased

Examination in SAM

- Temperature: fever (temperature 37.5 °C or more) or hypothermia (rectal temperature below 35.5 °C)
- Signs of shock: a combination of cold hands, capillary refill time greater than 3 s, a weak, fast pulse and lethargic or unconscious
- Signs of dehydration (caution: unreliable in the malnourished child)
- Oedema
- Pallor
- Localizing signs of infection (ear, throat, skin, chest)
- Mouth (ulcers, angular stomatitis, oral thrush)
- Vitamin A deficiency: dry conjunctiva/cornea, corneal ulceration, keratomalacia (bilateral softening and clouding of the cornea often with photophobia)

Box 2

due to wasting, poor cardiac output prolongs capillary refill time and decreased renal blood flow and function decrease urine output.

Signs of localized infection may be absent due to impaired immune responses. In endemic settings, every malnourished child should be assessed for HIV infection. Tuberculosis (TB) may co-present with malnutrition but diagnosis is challenging – particularly because the Mantoux test may be falsely negative. Where malnutrition does not respond to standard care, a trial of anti-TB treatment may be necessary.

Investigations

Access to investigations is likely limited in resource-poor settings. If blood glucose cannot be measured, presumptive treatment for hypoglycaemia should be initiated especially in hypothermic children. The presence and degree of anaemia may need to be assessed clinically. In malaria-endemic areas, it is usually possible to examine blood films for malarial parasites.

Even if available, measurement of plasma electrolytes may be misleading as detailed above; therefore, empirical management guides fluid therapy. Other investigations include a chest X-ray (to screen for pneumonia or TB) and HIV testing. Stool culture rarely helps in the management persistent diarrhoea but is indicated in dysentery.

Management

Where should malnourished children be managed?

The integrated management of SAM involves both in-patient and community services. Children with SAM and complications such as severe oedema, fever or diarrhoea are treated as in-patients. The management of marasmus and kwashiorkor follows the same principles. Failure to account for the abnormal physiology of SAM leads to avoidable deaths from hypoglycaemia, hypothermia, infection, electrolyte imbalance and heart failure from inadvertent fluid overload. Case fatality often exceeds 30%, nonetheless, a significant proportion of deaths are avoidable with optimal care. A review in two South African hospitals in 2000–2001 ascribed 50% of deaths to doctor error and 28% to nurse error.

In an attempt to improve outcomes, and address the multiple, co-existing abnormalities that occur in SAM, the WHO has produced a standard 10 step protocol consisting of two phases (Box 3). In the initial stabilization phase, the focus is to remedy the metabolic disturbances and stabilize the child's condition before entering the rehabilitation phase when weight should be regained.

The WHO 10 steps protocol

• Treat/prevent hypoglycaemia

Unless blood glucose ≥ 3 mmol/Litre can be demonstrated, hypoglycaemia should be presumed and treated with oral glucose: give 10% dextrose or a milk feed immediately. Only give intravenous glucose if the child is unconscious. Hypoglycaemia is prevented by frequent feeds (2 hourly) throughout the day and night.

• Treat/prevent hypothermia

Malnourished children are at high risk of hypothermia (axillary temperature less than 35 °C, rectal temperature less than 35.5 °C or unrecordable). An effective way of rewarming is kangaroo mother care. Assume both hypoglycaemia and infection and manage both appropriately.

• Treat/prevent dehydration

As clinical signs can be difficult to interpret, assume dehydration in all children with watery diarrhoea or reduced urine output. Avoid intravenous rehydration unless signs of shock are present due to the risk of precipitating heart failure. Enteral rehydration with ReSoMal (Rehydration Solution for Malnutrition) should be slower than usual.

• Correct electrolyte imbalance

Both ReSoMal and F-75 (the initial therapeutic milk) are appropriate for SAM as they contain reduced sodium and additional potassium. The extra potassium allows renal excretion of the excess sodium and oedema to gradually dissipate. Oedema should never be treated with diuretics.

• Treat/prevent infection

All children should be treated empirically with broad spectrum antibiotics. In complicated malnutrition, give antibiotics parenterally (e.g. IV benzylpenicillin plus IV gentamicin). Modify antibiotic regimens for specific infections such as meningitis. Consider treatment for malaria and measles vaccination and, during the rehabilitation phase, treatment for worm infestation. Strict hand washing and other infection control measures should be adhered to.

• Correct micronutrient deficiencies

F-75, F-100 (the therapeutic milk used in the rehabilitation phase) and ready-to-use therapeutic foods (RUTF) already contain sufficient minerals, vitamins (including vitamin A), and trace elements. Additional vitamin A should only be given if there are ocular signs of deficiency or a history of measles. Although malnourished children are usually iron-deficient, iron can exacerbate infections and supplementation should be delayed until the rehabilitation phase.

- **Start cautious feeding**

The milk feed recommended for the initial stabilisation phase is F-75 which can be made from locally available ingredients. Energy and protein content (75 kcal/100 ml and 0.9 g protein/100 ml respectively) and total feed volume are restricted to prevent heart failure, osmotic diarrhoea and worsening of oedema. Feeds are offered frequently (2–3 hourly including during the night) and the interval spaced as the child improves. Nasogastric tube feeding may be needed to achieve recommended intakes. Empowering mothers and carers to give feeds helps to overcome staff shortages.

- **Achieve catch-up growth**

Once medical problems and oedema are resolving, blood sugars are stable and appetite has returned, the child is ready for the transition to the rehabilitation phase. F-75 is gradually replaced with F-100 (100 kcal/100 ml and 2.9 g protein/100 ml) and/or RUTF. RUTFs are high energy and protein foods made from peanut paste, milk powder, oil and sugar, enriched with electrolytes, vitamins and minerals including iron. They keep for months at ambient temperature, they do not require cooking or mixing with water. This prevents microbial contamination even in the harsh environments of the developing world.

- **Provide sensory stimulation and emotional support**

It is vital to create a stimulating environment for malnourished children with as much carer involvement as possible, opportunities for play and physical activity.

- **Prepare for follow-up**

Once transition is completed, most children can be managed as out-patients. Rather than reaching specific anthropometric targets, the timing of discharge depends on family circumstances and on-going support available in a community programme. Caregivers should receive nutrition and health education including instructions when to seek medical care. They should understand the importance of follow-up appointments that aim to monitor weight gain and detect relapse early.

Box 3

Community-based therapeutic care (CTC)

Admission to hospital has several disadvantages including risk of nosocomial infections and high expense for the family. The health of the siblings and the consequences of removing the mother from the household should be taken into account. Children with uncomplicated SAM who are clinically well, and pass the appetite test, are best managed in the community. CTC achieves higher coverage than facility-based programs (over 70% vs 10% respectively in one study), and better patient retention and treatment outcomes. CTC was endorsed by WHO and UNICEF in 2009.

CTC is usually based in local health centres. At registration the child is given a course of broad-spectrum oral antibiotics and attends weekly for weighing and the distribution of RUTF appropriate to current weight. CTCs are generally popular with families but weight gain is usually not as rapid as in in-patient

programmes. RUTFs are very palatable and there may be a temptation to share rations with other children (and adults!) in the household sometimes in-keeping with cultural norms of sharing food.

CTC is also used to treat moderate malnutrition. The aim is to promote recovery by providing nutritious food rations preferably of locally available foods and appropriate health education and, critically, prevent progression to SAM.

Special groups

Infants younger than 6 months: the numbers of young infants with SAM with and without nutritional oedema are increasing. Possible reasons include increased survival of low birth weight/premature babies and failure to exclusively breastfeed related to maternal HIV-infection. An underlying organic cause or social issue, for example maternal depression, is more common than in older children with SAM. These mothers and other carers might need special support.

The threshold for admission is lower but the same management principles apply as for older children. Try to identify any issues with breastfeeding and re-establish effective breastfeeding either by the mother or a wet nurse. Use expressed breastmilk if the child is too unwell to suckle. A commercial infant formula milk with appropriate precautions against bacterial contamination, F-75 or diluted F-100 are options if breastfeeding is not possible. It is important to review vaccination status before discharge and catch-up with the schedule whenever possible.

HIV positive children: if the population HIV prevalence is more than 1%, WHO recommends routine counselling and testing of all children with SAM. In HIV endemic settings, up to 50% of children with SAM may be HIV-infected. Management of SAM is the same as for HIV-negative children but with the addition of prophylactic co-trimoxazole. Severe oral thrush may need treatment with fluconazole. Anti-retroviral treatment should be started after the stabilisation phase and follows the same regimen as for children without SAM. Staff may need encouragement that many HIV-infected children respond well to nutritional rehabilitation although this may take longer and treatment failures are more common.

Prevention

As detailed above, the management of SAM presents a huge challenge, especially in inadequately resourced health facilities. Even when the WHO 10 steps are applied rigorously, mortality often remains high. Therefore, prevention of malnutrition is a priority for governments and other organizations dedicated to improving child health. As malnutrition results from a complex interplay between health and socioeconomic adversities, a range of interventions across multiple sectors are necessary. Nutrition-specific interventions target undernutrition directly, such as SAM treatment, CTC or micronutrient interventions. Nutrition-sensitive programs address underlying causes such as water safety and sanitation.

Community-based interventions focus on the prevention of chronic malnutrition as evidenced by stunting. In 2012, the World Health Assembly declared a 40% reduction of stunting by 2025 as a global target. Although catch-up growth during

Key points for SAM management

- Nutritional status should be assessed in all children presenting to healthcare facilities
- Treatment of SAM should be standardized and take account of reductive adaptation to prevent avoidable deaths. Where possible, treatment should be community-based but children with complicated SAM will need intensive in-patient management
- Strategies to prevent malnutrition should be multi-sector, aimed at both individuals and communities and tackle the wide range of health, social and economic causes

Box 4

adolescence might be possible, the first 1000 days, from conception to age 2 years, are considered a “window of opportunity” for normal growth and development. International initiatives such as the Scaling up Nutrition (SUN) movement target this period to prevent stunting. With all interventions, promoting equity to ensure that they reach the most vulnerable children remains a challenge.

An essential preventive strategy is the promotion of breastfeeding. The WHO recommends exclusive breastfeeding until 6 months of age with supplementary breast milk as important part of the diet up to 2 years of age. The uncompromising guidelines of the Baby Friendly Hospital Initiative, now familiar in many UK maternity units, were originally intended for the developing world where exclusive breastfeeding is a truly life-saving intervention.

Other interventions include the promotion of nutrient-rich weaning foods and increasing coverage of immunizations and vitamin A supplementation. Primary care services must also ensure the prompt treatment of childhood illnesses that can precipitate or worsen malnutrition. Improvement of a community's sanitation and hygiene via the provision of toilets and the promotion of handwashing with soap are also critically important. For mothers to act as effective advocates for their children, the broader aim of empowering women and improving levels of female education must be addressed. During pregnancy, protein and energy supplementation, rather than micronutrient supplementation alone, may be more effective in increasing birth weight.

The fact that many developing countries will fail to achieve the MDG4 target highlights the need to confront childhood undernutrition as a critically important risk factor for ill health in the world today. The existing evidence for the effectiveness and cost-effectiveness of several interventions, such as exclusive breastfeeding and improved sanitation, should aid governments and society in eradicating this scourge on the health and well-being of so many of the world's children (Box 4).

Role of the funding sources

None. ◆

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