Overview of enteral nutrition in infants and children

Authors: Sarah E Fleet, MD, Christopher Duggan, MD, MPH
Section Editor: Kathleen J Motil, MD, PhD
Deputy Editor: Alison G Hoppin, MD

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INTRODUCTION

Enteral nutrition is defined as providing nutrients via the gastrointestinal tract. Although the term technically refers to nutrition given either by mouth or through a feeding tube, in common usage, the term usually refers to tube feeding and includes feeding via nasogastric tube, gastrostomy tube, gastro-jejunostomy tube, or jejunostomy tube. In comparison with parenteral nutrition (the provision of nutrients via a venous catheter directly into the bloodstream), enteral nutrition offers several advantages, including lower costs, beneficial effects from utilization of the gastrointestinal tract, and avoidance of the many potential complications of parenteral nutrition.

For many pediatric patients with suboptimal nutrition, intake by mouth can be improved by offering high-calorie foods, oral supplements, or boosting the nutrient density of foods by adding high-energy supplements such as fats (oils, cream, or butter), carbohydrates (sugars and powdered supplements), and proteins (milk or other protein powders). Children who are still unable to take in sufficient energy through these approaches, or those who are unable to tolerate oral feedings because of underlying disease, are candidates for enteral nutrition.

Related content can be found in the following UpToDate topic reviews:

- **Nutritional assessment**:
  - (See "Measurement of growth in children".)
  - (See "Indications for nutritional assessment in childhood".)
  - (See "Poor weight gain in children younger than two years in resource-abundant countries: Etiology and evaluation".)
- **Artificial nutrition support**:
  - (See "Parenteral nutrition in infants and children".)
  - (See "Parenteral nutrition in premature infants".)
  - (See "Approach to enteral nutrition in the premature infant".)

- **Specific disease states**:
  - (See "Management of short bowel syndrome in children".)
  - (See "Growth failure and poor weight gain in children with inflammatory bowel disease".)

NUTRITIONAL ASSESSMENT IN CHILDREN

The decision about whether to initiate enteral nutrition in children should begin with a thorough, reliable, and valid evaluation of nutritional status.

General evaluation — The general assessment of nutritional status begins by obtaining, plotting, and interpreting weight, length, and head circumference data on sex- and age-specific growth curves. For full-term infants and children up to 24 months of age, the growth charts developed by the World Health Organization (WHO) should be used; these standards were derived from healthy infants who were exclusively breastfed [1]. For children 2 to 20 years old in the United States, the growth charts developed by the Centers for Disease Control (CDC) should be used. These growth charts include curves for weight for age, length (height) for age, as well as body mass index (BMI), on which an individual patient's values can be plotted and tracked over time. (See "Measurement of growth in children", section on 'Recommended growth charts with calculators'.)

For premature infants, evaluation of the degree of prematurity is critical and often leads to a decision to initiate tube feedings until oral feeds are possible. Enteral and/or parenteral nutrition usually is required until a premature infant reaches approximately 34 weeks gestational age. Appropriate growth curves or correction for gestational age should be employed when judging the nutritional status of premature infants. The evaluation for and management of enteral feeds in premature infants are discussed in separate topic reviews. (See "Approach to enteral nutrition in the premature infant" and "Growth management in preterm infants", section on 'Normative growth data'.)

Determination of malnutrition — In general, deficits in weight for age are classified as "underweight," deficits in length for age are classified as "stunting," and deficits of weight for length are classified as "wasting" (figure 1). The severity of the deficits are categorized using Z-scores, which can be obtained from these calculators:

- Infants zero to two years
  - Girls (calculator 1)
  - Boys (calculator 2)

- Children two to five years
  - Girls (calculator 3)
  - Boys (calculator 4)

Details and comparison of techniques for assessing malnutrition in children are discussed in a separate topic review. Nutritional assessment with standard anthropometric criteria are equally valid for children in resource-poor countries as for those in resource-rich countries. (See "Malnutrition in children in resource-limited countries: Clinical assessment", section on 'Clinical assessment'.)

Anthropometric measures of the arm provide helpful and supplementary data, especially in clinical scenarios when measurement of body weight is not possible or is inaccurate, or when height cannot be accurately measured (eg, cerebral palsy, critical illness). These include measures of triceps and/or biceps skinfold thickness (TSF and BSF, respectively) and mid-upper arm circumference (MUAC). TSF and BSF are measured with a skin fold caliper and MUAC with a non-stretchable tape measure, both measured by trained personnel. Standard equations can calculate mid-arm muscle area (MAMA) from TSF and MUAC. MAMA is an estimate of peripheral lean body mass, and TSF and BSF are reasonable estimates of peripheral body fat composition (though not central adiposity). (See "Measurement of body composition in children", section on 'Anthropometrics'.)

Global nutritional assessment — The American Society of Parenteral and Enteral Nutrition (ASPEN) recommends combining the anthropometric data described above with other clinical information to classify a child's malnutrition using the following categories [2,3]:

- Illness-related versus non-illness-related – If illness-related (caused by disease, surgery, or trauma), include the presumed mechanism for the malnutrition (eg, decreased intake, increased requirement, or excessive loss of nutrients). If non-illness-related (caused by environmental or behavioral factors), describe the proximal causes of the starvation, eg, anorexia, socio-economic, iatrogenic feeding interruptions, or intolerance.

- Acute versus chronic – Use a cutoff of three months' duration.

- Severe versus moderate – Use Z-scores for "key anthropometric variables" (weight, height, BMI, and MUAC) to define the presence and severity of malnutrition (figure 1).

- Effects on growth – Serial anthropometric measurements of weight and length are optimal, if available. In general, a Z-score decrease of more than 1 in an individual anthropometric measurement indicates faltering growth in height and weight.

- Functional status – Assessment of the effects of the malnutrition on the child's functional status.

Several nutrition screening tools have been developed for use in hospitalized children:

- The Subjective Global Nutrition Assessment (SGNA) (table 1) provides one approach; it is designed to guide a thorough assessment of current nutritional status [4].

- The STRONGkids tool (table 2) is designed to predict nutritional risk; ie, negative weight for height standard deviation scores, hospital length of stay, and need for supplementary feeding in children [5-7]. It is relatively simple and practical to use.

- Other tools are the Nutrition Risk Score (NRS) [8], the Pediatric Nutritional Risk Score (PNRS) [9], the Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP) [10], the Paediatric Yorkhill

Malnutrition Score (PYMS) [11], the Pediatric Screening Nutrition Tool (PNST) [12], and the Pediatric Digital Scaled Malnutrition Risk screening Tool (PeDiSMART) [13].

The aim of all of these screening tools is to identify children at risk of malnutrition on hospital admission and determine the need for nutritional intervention during hospitalization. However, there are differences in the use of these tools. For example, SGNA is designed to evaluate the **actual** nutritional status of a child on admission, whereas STRONGkids is designed to predict the **risk** of children becoming malnourished during the hospital stay. A tool that predicts nutritional risk during the hospital admission may be more valuable because it is tied to clinical decision-making about nutritional interventions. However, a systematic review concluded that there is insufficient evidence to select one of these tools over the others, based on predictive accuracy [14].

INDICATIONS FOR ENTERAL NUTRITION

General indications — Any child who is unable to meet nutritional requirements by mouth is a candidate for enteral nutrition. The decision to treat and the route of supplementation depends on the underlying disease, its severity and anticipated course, and several other patient-specific considerations.

Regardless of the technique used for nutritional assessment, preexisting undernutrition (as defined by low birth weight, underweight, or wasting) is an indication to begin enteral nutrition sooner than among well-nourished subjects. In undernourished infants and children, repletion of body weight is a primary goal for enteral nutrition and measure of its efficacy.

Indications for enteral nutrition generally fall into one of the following categories:

- **Impaired swallowing or oral motor development, or oral aversion** – Underlying conditions include cerebral palsy or other neurologic problems (resulting in spasticity or poor coordination of skeletal muscles involved in eating), congenital anomalies of the gastrointestinal tract, and prematurity (in which developmental skills in oral intake are incomplete).

- **Excessive metabolic demands** – Infants with sepsis, congenital heart disease, or bronchopulmonary dysplasia or children with critical illness commonly require enteral feeding to meet their nutrient needs, which may be increased by the illness. As compared with adults, infants and children have proportionately lower reserves of body protein, carbohydrate, and fat and also have increased metabolic needs [15,16]. As a result, the threshold for beginning supplemental enteral nutrition is also lower than in adults: In infants and children with these diseases, insufficient oral intake for three to five days is a suitable threshold for intervention.

- **Impaired absorption or digestion** – This broad category includes children with short bowel syndrome, cystic fibrosis, Crohn disease, some inborn errors of metabolism, chronic renal insufficiency, and others. The indications and type of enteral nutrition vary depending on the underlying condition, as discussed below.

Specific disease states — The following sections present an overview of the indications for enteral nutrition for each of several disorders or categories. More details are available in the linked topic reviews.

Congenital heart disease — Growth failure is a common complication of congenital heart disease. Malnutrition is probably caused by several mechanisms: These patients often have increased energy requirements due to increased work of breathing and cardiac effort and may have malabsorption from poor oxygen delivery to the intestine. In addition, they often have inadequate energy intake because of anorexia, early satiety, and general feeding intolerance, caused by congestive heart failure that leads to dyspnea, tachycardia, and fatigue [17,18]. The severity and type of growth failure depends in part on the type of cardiac defect: Cyanotic defects are typically associated with poor gains in both weight and length, while infants with acyanotic defects have poor weight gain but relatively preserved linear growth. Chronic hypoxia can be another factor resulting in poor growth.

Children with growth failure due to congenital heart disease may not be able to meet their energy needs with oral feeds alone and often require enteral feeding support. In some cases, infants and young children with congenital heart disease also have ischemic bowel disease, with mucosal damage and sometimes requiring surgical resection, so specialized formulas may be indicated. However, the majority of children with CHD can tolerate enteral feeding with intact protein formulas. (See "Diagnosis and initial management of cyanotic heart disease in the newborn" and "Management of isolated ventricular septal defects in infants and children", section on 'Nutritional support'.)

Cystic fibrosis — Children with cystic fibrosis frequently have growth failure, caused by the combination of malabsorption, increased energy needs, and reduced appetite. Initiation of enteral feedings is appropriate if the child's body mass index (BMI) cannot be kept in the target range (BMI at or above the 50^{th} percentile for age) despite optimization of pancreatic enzyme therapy and oral nutrition support. (See "Cystic fibrosis: Nutritional issues", section on 'Nutrition support'.)

Gastrointestinal disease and dysfunction

- **Short bowel syndrome** – Both enteral and parenteral feeding are required for many infants and children with short bowel syndrome or other forms of intestinal failure [19,20]. Even small quantities of enteral feeding promote intestinal adaptation and enhance feeding tolerance; continuous feeding is usually better tolerated than bolus feeding. Over time, enteral feeds can and should be gradually increased to supply an increasing proportion of the patient's nutritional needs. Reducing dependence on parenteral nutrition is particularly important in infants with short bowel syndrome, who are at high risk for developing intestinal failure-associated liver disease and numerous complications from central venous line catheters. (See "Management of short bowel syndrome in children", section on 'Advancement of enteral feeds' and "Intestinal failure-associated liver disease in infants".)

- **Inflammatory bowel disease** – Children with inflammatory bowel disease (IBD), and particularly those with Crohn disease, frequently have nutritionally- and inflammatory-mediated deficits in growth that often precede the diagnosis of the IBD. At the time of diagnosis of Crohn disease, approximately 25 percent of children have low body weight, 80 percent have reduced height velocity, and most have delayed pubertal development. (See "Growth failure and poor weight gain in children with inflammatory bowel disease", section on 'Clinical consequences'.)

Nutritional support for children and adolescents with IBD depends on the degree of nutritional deficits and response to medical treatment of the IBD, ranging from dietary counseling, to liquid supplements taken by mouth, to supplemental enteral nutrition. Close monitoring of nutritional status and growth and a proactive approach to supplemental nutrition is important to optimize growth and minimize consequences of malnutrition, including bone disease. Increasingly, exclusive enteral nutrition (in which all nutritional needs are supplied as a liquid formula, taken by mouth or through enteral feeds) is used as primary therapy for the IBD itself. (See "Growth failure and poor weight gain in children with inflammatory bowel disease", section on 'Intervention' and "Overview of the management of Crohn disease in children and adolescents", section on 'Exclusive enteral nutrition'.)

- **Biliary atresia** – Nutritional problems in infants and children with biliary atresia and other cases of chronic cholestatic liver disease are common and difficult to overcome. They are caused by a combination of malabsorption due to cholestasis and chronic liver inflammation. Depending on the severity of the nutritional deficit, this is managed by increasing the energy content of oral feeds or by enteral nutrition, given by nasogastric tube and/or changing to a formula with higher medium-chain triglyceride (MCT) oil content. Special attention should be paid to ensuring adequate fat-soluble vitamin status in children with this disorder or other causes of chronic cholestasis. (See "Biliary atresia", section on 'Nutrition'.)

Renal disease — Children with chronic kidney disease frequently have nutritional problems due to poor appetite, and metabolic acidosis, which can impair growth and cognitive development. Nutritional management of children with chronic kidney disease focuses on their unique energy, protein, vitamin, mineral, and electrolyte needs and is discussed in a separate topic review. (See "Hemodialysis for children with chronic kidney disease", section on 'Inadequate nutrition' and "Chronic kidney disease in children: Complications".)

Growth may be further impaired by altered growth hormone production and metabolism, and this component responds to treatment with recombinant growth hormone. (See "Growth hormone treatment in children with chronic kidney disease and postkidney transplantation".)

Critical illness and postoperative states

- **General measures** – Infants and children with critical illness and those who are undergoing surgery are often thought to be hypermetabolic and in need of specialized nutrition support. The extent of hypermetabolism varies substantially, however, and is difficult to predict with certainty [21]; it may be less common with modern techniques for anesthesia and pain control [22,23]. Overfeeding should be avoided because it increases the ventilatory work by increasing carbon dioxide production and can induce hepatic steatosis, cholestasis, and hyperglycemia [17,24]. Critically ill children with mild to moderate hyperglycemia do not seem to benefit from tight glycemic control with insulin infusions [25]. (See "Glycemic control in critical illness".)

Children with critical illness should undergo nutritional assessment upon entry into the intensive care unit (ICU) to identify preexisting nutritional problems (either underweight or overweight) as well as risk factors for the development of nutritional complications (including expectations for when the patient will be able to eat and predicted metabolic needs) due to critical illness or its therapy. Body weight should be measured on admission and periodically remeasured during the hospital stay. Serial measurements of weight are often overlooked in the ICU but provide critical information about changes in the patient's nutritional and fluid status [26]. Standard equations can be used to estimate energy needs but are often unreliable and can either underestimate or overestimate needs [27]. Therefore, the use of indirect calorimetry to measure energy needs has been recommended [24,28-30]. Periodic reassessment of nutrition needs and monitoring of actual input is important because energy requirements change during the course of an illness and because the quantity of enteral feeds actually administered is often well below the intended target due to interruptions in the feeding schedule due to intolerance or competing medical procedures, such as fasting prior to medical procedures [17,31,32].

- **Burns** – Children with thermal injury have increased requirements for energy and protein, which must be met to achieve optimal outcomes. Their micronutrient status is likely altered as well [17,33]. This is due in part to a hypermetabolic response to the burn injury, which markedly increases energy needs. As an example, the metabolic rate in children with burn injuries of more than 40 percent of their body surface area increases by approximately 180 percent and remained elevated at 150 percent even after full healing of the wound [34]. As a result of these increased needs, nutritional support should be given to patients with moderate or severe burns (based on burn depth and surface area) within 24 to 48 hours of the injury, if the patient is stable but unable to consume sufficient calories by mouth. Nutritional management of patients with severe burns, including formula selection and equations for estimating energy needs in children, are discussed in a separate topic review. (See "Nutritional demands and enteral formulas for adult surgical patients".)

  The hypermetabolic response to the injury also causes increased protein catabolism with muscle wasting, and peripheral insulin resistance, which leads to hyperglycemia. The prevention of hyperglycemia with intensive regimens including exogenous insulin has also been shown to improve outcomes in children with burns [35-38]. However, maintaining a continuous insulin infusion in burn patients is difficult because of the need for frequent interruptions in their enteral feedings, with associated risks for hypoglycemia. These and other issues related to the hypermetabolic response in adults and children with burn injuries are discussed in a separate topic review. (See "Hypermetabolic response to moderate-to-severe burn injury and management", section on 'Glycemic control' and "Overview of nutrition support in burn patients", section on 'Glycemic control'.)

- **Cancer** – Nutritional management of patients with cancer is critical during active disease and during the treatment regimens. Treatment such as chemotherapy, radiation, or surgery may cause anorexia, poor oral tolerance, and inadequate intake. Energy requirements are variable depending on stress and state of catabolism and may be impacted by tumor burden. Tube feedings for total intake or as a supplement to oral intake can be considered to support a patient during treatment and when anorexia occurs. Standard feedings can be used unless there are issues with malabsorption, in which case a semi-elemental feeding may be advantageous.

Patients undergoing hematopoietic stem cell transplantation are particularly likely to require nutritional support. In some cases, especially with allogeneic transplantation, they require parenteral rather than enteral nutrition due to gastrointestinal dysfunction from preparative chemotherapy and radiation. These children may have lower energy needs than predicted by standard equations [39], so direct measurement of nutritional needs by indirect calorimetry can help target energy intake [40].

Neuromuscular impairment — Neuromuscular disease may either decrease or increase energy requirements. As examples, children with choreoathetoid cerebral palsy (but not spastic cerebral palsy) tend to have increased energy expenditure, whereas those with Down syndrome or myelomeningocele generally have lower energy requirements than expected for their age and size. The energy requirement also may depend on the child's nutritional status: The resting energy expenditure of malnourished children with severe cerebral palsy tends to be lower than expected prior to a nutritional intervention but rises to normal after supplemental feeds are begun [41]. This pattern is similar to that seen in other children with malnutrition. Because of the variable energy needs of neurologically impaired children, it is important to monitor a child's nutritional status before and after beginning a nutrition intervention and readjust energy intake as needed.

Some children with neuromuscular impairment are also at risk for aspiration due to swallowing dysfunction and/or gastroesophageal reflux; these are important considerations when selecting the route and regimen for enteral nutrition. (See "Aspiration due to swallowing dysfunction in children".)

Although concentrated formulas may be useful to reduce gastric volume and the risk of gastroesophageal reflux, it is also important to ensure that the patient receives sufficient fluid. Maintenance fluid requirements depend on the child's weight and can be estimated using a simple equation or calculator (calculator 5 and calculator 6). Considerations including individual variations in water loss are discussed in a separate topic review. (See "Maintenance intravenous fluid therapy in children".)

FORMULA SELECTION

Selection of a formula for enteral feeding depends on the age, weight, and degree of prematurity of the infant or child, as well as his or her gastrointestinal, renal, and other metabolic functions.

Other considerations include whether the child has dietary protein sensitivities or carbohydrate or fat malabsorption. Selection of formula may also depend on the severity of any underlying illness and/or the presence of critical illness (where gastrointestinal function can often be impaired in patients with prolonged disuse).

Types of formulas or feeds — Since allergic or intolerance disorders are common indications for special formulas, the formulas are commonly grouped by the protein source and/or extent of hydrolysis. We generally avoid the use of the terms "elemental" or "semi-elemental" in describing formulas since these terms are nonspecific and can be inaccurate (eg, some "elemental" formulas include intact fat sources).

- **Cow's milk protein formulas** are composed of intact, cow's milk-derived proteins and are typically used for standard formulas for all ages. These can be used for enteral nutrition for most infants and children.

- **Soy protein-based formulas** are tolerated by most infants with an immunoglobulin E (IgE)-mediated cow's milk allergy if human milk is not available, particularly in infants >6 months of age [42,43] (see "Food allergens: Overview of clinical features and cross-reactivity", section on 'Cow's milk'). They are not recommended for the prevention of food allergies or for feeding infants at risk for allergic disease (eg, siblings or children of an individual with allergic disease). Soy formulas are generally not recommended for infants with food protein-induced proctocolitis, because many of these infants are sensitive to both cow's milk and soy protein. Extensively hydrolyzed formulas are generally preferred for such infants. (See "Food protein-induced allergic proctocolitis of infancy", section on 'Formula-supplemented or formula-fed infants'.)

  Soy formulas also can be used for feeding infants if a vegan diet is preferred by the family since the protein source is from plants, or for infants with galactosemia since the carbohydrate source is lactose-free. (See "Galactosemia: Management and complications".)

- **"Blenderized" feedings** are made from intact, table-food products that are liquified in a food blender to allow administration through an enteral tube. This approach is increasingly selected by families because of reduced cost, desire to share a family mealtime experience with their enterally fed child, and/or perception that table foods are healthier than conventional formulas [44]. For homemade blenderized feedings, families need to be willing to invest time to prepare the blenderized formula and to follow proper food safety measures [45]. In addition, hang times for homemade blenderized feedings are recommended to be two hours or less for food safety reasons.

  Commercial blenderized formulas are also available, and some are nutritionally complete (ie, they meet estimated needs for energy and all macro- and micronutrients, when provided in the appropriate volume for the patient's age group). Since these commercial formulas are aseptic, their hang time is not limited to two hours. Some of the newer commercial blenderized products may not be covered by insurance and may or may not be nutritionally complete, so these require careful planning to ensure that micronutrient and fluid needs are met.

  Use of blenderized formulas require larger bore (16 to 18 Fr) gastrostomy tubes to prevent clogging, and they are not recommended for infusion via jejunostomy tubes. This approach is most practical for use if the patient can tolerate bolus feedings via syringe; this avoids use of a pump, which tends to cause more problems with occlusion. As with all enteral formulas, ongoing monitoring for tolerance, adequacy, and growth is essential.

- **Extensively hydrolyzed protein formulas** are made from cow's milk protein that is extensively hydrolyzed. Although the shorter chain length of these hydrolyzed proteins makes them less likely to elicit an immunologic response in susceptible children, these formulas are not truly "hypoallergenic." These formulas are appropriate for most infants with food protein-induced proctocolitis or IgE-mediated cow's milk allergy. Most are lactose-free, and most have a component of medium-chain triglycerides (MCT), which can be useful in cases of fat malabsorption. Of note, formulas that are partially hydrolyzed are also available. (See "Food protein-induced allergic proctocolitis of infancy".)

- **Amino acid-based formulas** are made from free amino acids and are indicated for patients with severe cow's milk protein allergy or multiple food allergies including some cases of eosinophilic esophagitis. They are sometimes used for individuals with short bowel syndrome if human milk is not available, because such infants are prone to food allergies, and also to help manage their malabsorption. These formulas are also lactose-free, and some contain medium-chain fats, which may enhance fat absorption. However, elemental formulas have a higher osmotic load than human milk and so may not be tolerated by all infants. Moreover, monitoring is warranted because certain amino acid-based formulas (some formulations of Neocate brand) have been associated with hypophosphatemia and rickets, as described in case series [46]. (See "Management of short bowel syndrome in children", section on 'Initiation of enteral feeds' and "Overview of rickets in children", section on 'Phosphopenic rickets'.)

Age considerations — Formulas are further categorized by age group of the recipient. Each is designed to be nutritionally complete if given to the appropriate age group and in the appropriate quantity.

Infants — Formulas for infants (table 3), which are designed to be similar to human milk, are typically lower in caloric density, calcium, and phosphorus compared with formulas for toddlers and children. Infant formulas need to be provided in volumes of 150 to 175 mL/kg/day to provide recommended requirements of energy, vitamins, and minerals (if given at standard concentrations). Younger infants or those needing catch-up growth will be on the higher end of this range. Infants with growth failure may need infant formulas concentrated to 22 or 24 kcal/oz to ensure adequate energy, protein, and mineral intake to promote catch-up weight gain.

In healthy infants older than six months of age, infant formulas are generally supplemented with complementary feedings, so they do not rely on formula alone to meet nutrient needs. On the other hand, older infants and children who are receiving the bulk of their nutrition via enteral nutrition due to gastrointestinal or other diseases often rely on formula for all of their nutritional needs. The total fluid, energy, and macro- and micronutrient needs of these patients therefore should be reviewed serially.

Toddlers and older children — After one year of age, a variety of formulas are available, depending on the child's needs and some disease-specific considerations (table 4A-B). For children between 1 and 10 years of age, formulas are generally designed to have higher micronutrient concentrations as compared with formulas for adults. For children 10 years of age and older, formulas designed for adults usually can be used.

Concentrated formulas are available in caloric densities up to 2 kcal/mL and may be useful in some children with high caloric needs and low fluid tolerance. However, these formulas are typically hyperosmolar and can lead to diarrhea and dumping syndrome if infused rapidly, or to intravascular volume depletion if adequate fluids are not supplied.

Specialty formulas — Specially designed formulas are valuable for treating specific metabolic conditions, such as phenylketonuria or other inborn errors of metabolism, or intractable seizures requiring a ketogenic diet. The formula is specific to the disease condition and affected individuals require close monitoring. (See "Ketogenic dietary therapies for the treatment of epilepsy" and "Overview of phenylketonuria".)

There is less evidence to support the widespread use of formulas designed for disease conditions such as glucose intolerance, hepatic, pulmonary, or renal disease. Studies of most of these formulas in adults have not shown consistent benefit, as discussed in a separate topic review. (See "Nutrition support in critically ill patients: Enteral nutrition", section on 'Critical illness'.)

NUTRITIONAL REQUIREMENTS

When initiating enteral feeds, the target volume is calculated based on estimated needs for fluid and energy. These are only estimates, and actual needs vary substantially [47]. Therefore, in all children on enteral feeds, weight gain and growth should be reassessed periodically and the regimen adjusted to optimize growth. The clinical goal is to achieve a growth pattern that follows along the curves of the World Health Organization and Centers for Disease Control and Prevention (WHO/CDC) growth charts.

Children with healthy growth — The recommended dietary allowance (RDA) provides an estimate of the energy or protein needs that meets the needs of most healthy individuals in an age group, allowing for optimal growth for their genetic potential. Initial goals for enteral feeds are based on estimated energy requirements, then adjusted as needed to maintain normal rates of weight gain.

- **Preterm infants** – For enterally fed preterm infants, the goal during hospitalization is for an energy intake of 120 kcal/kg per day, which is equivalent to 150 to 160 mL/kg per day of preterm formula (24 kcal/oz or 80 kcal/100 mL) or fortified human milk. Target growth rates are approximately 15 to 18 g/kg per day until the infant is approximately eight weeks post-term. (See "Growth management in preterm infants".)

- **Term infants** – Average energy requirements in healthy infants are approximately 110 kcal/kg/day at 1 month of age, 95 kcal/kg/day at 3 months of age, and 80 kcal/kg/day between 6 and 12 months of age (figure 2), based on estimates from the WHO [48]. Target growth rates for healthy infants are approximately 30 g/day until 3 months of age, 20 g/day from 3 to 6 months of age, and 11 to 15 g/day from 6 to 12 months of age [49].

- **Children 12 to 24 months** – Between 12 and 24 months, energy requirements are 80 to 84 kcal/kg/day (table 5) [50]. Targeted growth rates are depicted by the WHO growth curves. (See

"Measurement of growth in children", section on 'Infants 0 to 2 years'.)

- **Children** – For children three years and older, estimates prepared by the Institute of Medicine (IOM) are most commonly used, ranging from 100 kcal/kg/day in three-year-old children to 40 to 50 kcal/kg/day in adolescents [51]. For young children, the IOM estimates are somewhat higher than those prepared by the WHO (table 5). Targets for growth are depicted in standard growth charts. (See "Measurement of growth in children", section on 'Children and adolescents 2 to 20 years'.)

  Ranges for energy and protein needs in each age group are shown in the table (table 6), and variations of the estimated energy requirements (EER) based on activity level are available from the United States Department of Agriculture (USDA) website. (See "Dietary history and recommended dietary intake in children", section on 'Dietary reference intakes'.)

These goals can be used to plan the initial enteral feeds for children whose growth is within a healthy range and who do not have a disorder causing hypermetabolism or malabsorption. In children with hypermetabolism or malabsorption, energy and protein needs will be increased, as discussed above. (See 'Indications for enteral nutrition' above.)

Children needing catch-up growth — If catch up growth is necessary, the energy and protein needs will be increased, and the following equations can be used to estimate needs.

- Energy needs (kcal/kg/day) = EER for age (kcal/kg/day) × ideal weight for height (kg)/actual weight (kg)

- Protein needs (g/kg/day) = RDA for protein for age (g/kg/day) × ideal weight for height (kg)/actual weight (kg)

  Where EER = estimated energy requirement; RDA = recommended dietary allowance.

Children with malabsorptive states such as short bowel syndrome or cystic fibrosis will likely need greater than the RDA amount of energy to support normal growth. The same situation may apply for children who are hypermetabolic, such as unrepaired cardiac defects or severe burns.

Adjustments for children with obesity — For children with obesity (body mass index [BMI] >95th percentile) requiring chronic enteral feeds, the clinical goal should be to provide energy and protein to achieve very gradual weight loss (eg, one to two pounds per month). One approach is to target an energy intake approximately 200 kcals below the usual range for the child's age group (table 6). The intake can then be adjusted up or down to achieve gradual weight loss. When energy needs are restricted, it is imperative to evaluate the adequacy of other macronutrients and micronutrients provided in the volume of formula administered. Additional protein, calcium, sodium, potassium, and/or vitamin D may be required. In young children with obesity admitted for intercurrent illnesses, energy restriction to promote weight loss is probably not useful and may impede recovery from the illness.

Monitoring — For patients on long-term enteral feeds, the adequacy of energy intake is monitored by serially measuring height and weight and plotting the results on a growth curve. For those with suboptimal growth, the energy intake can be increased by increasing feeding volume and/or concentration.

For these patients, we also suggest periodic assessment of routine blood chemistries (eg, electrolytes, blood urea nitrogen [BUN], calcium, phosphorus, magnesium, zinc, iron, and fat-soluble vitamins) to ensure optimal nutrition. These measures are most important in patients with underlying disorders that put them at risk for malabsorption and for those with malnutrition.

ADMINISTRATION

Small-gauge flexible feeding tubes made from silicone or polyurethane are well suited for providing enteral feeds to children. Access can be intragastric (eg, orogastric, nasogastric, or gastrostomy tubes) or transpyloric (eg, nasoduodenal or nasojejunal). The choice depends on whether the anticipated need for enteral feeds is short or long term and whether there is an aspiration risk:

Short-term needs — Naso- or orogastric access can be used for infants and children who are predicted to have only short-term need for enteral feeds (eg, less than three months). In addition, they are often used as an interim measure to feed and assess tolerance of enteral feedings before placement of a gastrostomy tube for longer-term enteral feeding. Placement of a nasogastric or orogastric tube does not require surgery or endoscopy, and parents or caregivers can be taught how to replace the tube at home. Potential disadvantages with this route are interference with oral intake, easy dislodgement, irritation to the nasal/oral area, infection, and, for older children, stigmatization with visible tube in place. The nasogastric route usually is preferred over gastrostomy for patients with portal hypertension because of the propensity to develop varices around the site of a gastrostomy. (See 'Gastrointestinal disease and dysfunction' above.)

A soft, flexible feeding tube (eg, made from polyurethane or silicone) should be used if possible. Tube sizes of 4 Fr should be used for neonates and infants and 8 Fr for children and adolescents. Smaller tubes are more comfortable for the patient but may become clogged more quickly with formula and medication administration.

Long-term needs — Gastrostomy tube feeding usually is appropriate if long-term enteral feeding is required, and they are usually easily placed laparoscopically or endoscopically. The gastrostomy can be fitted with a device that is easy to cover with clothes. Disadvantages of gastrostomy placement include local irritation, infection or granulation tissue, leaking, allergic reaction, and possible dislodgement [52].

Bolus intragastric feedings are generally preferred over continuous feeds if they can be tolerated since they provide a more normal pattern of eating and can deliver larger volumes over a shorter period of time (generally 10 to 20 minutes per bolus). If the patient can tolerate a bolus by gravity infusion, a pump is not necessary. Bolus feeds may also reduce the risk of aspiration because they are typically administered while the infant or child is awake and upright. On the other hand, the bolus method feeding might also increase the risk of pulmonary aspiration if large volumes are given. If a bolus feed is given while the child is asleep, the head of the bed should be elevated to least at a 45 degree angle to help reduce aspiration risk.

Continuous feeding regimens are useful for infants and children who do not tolerate bolus feeds, either because of malabsorptive disease (eg, short bowel syndrome), feeding intolerance (eg, many infants with congenital heart disease), or gastroesophageal reflux with aspiration risk (eg, some children neurologic impairment). This method requires a pump and appropriate measures to ensure freshness of the formula or human milk in the reservoir. In addition, continuous nocturnal feeding is used for some children with a chronic illness to supplement to their daytime oral intake (eg, children with cystic fibrosis and growth failure). When feeds are given while the child is asleep, the head of the bed should be elevated, as described above for bolus feeds. Some children may have an additional surgical procedure (eg, a fundoplication) to provide additional protection against gastroesophageal reflux and aspiration.

Unless contraindicated by the patient's condition (eg, aspiration risk), some feeds should be provided by mouth even if this provides minimal caloric content, because patients who are not fed by mouth often develop a feeding aversion that can interfere with the transition back to oral feeds [53,54]. The risk for developing feeding aversion is highest in infants and young children and if there is a prolonged period of time without oral feeds (eg, months to years). (See "Management of short bowel syndrome in children", section on 'Oral feeding'.)

Poor gastric emptying or aspiration risk — Transpyloric or postpyloric feedings may be required for infants and children with poor gastric emptying and/or aspiration risk; they reduce but do not eliminate gastroesophageal reflux [55,56]. (See "Enteral feeding: Gastric versus post-pyloric".)

Postpyloric feeding is given through a nasojejunal (NJ) or gastrostomy-jejunal combined tube (GJT), or occasionally with a surgically placed jejunostomy tube (JT). Postpyloric feeding requires a pump and an intermittent continuous infusion schedule of feedings because infusion of boluses directly into the small intestine results in dumping syndrome and is contraindicated. Small pumps are available and can be carried by the child in a backpack to allow mobility. Standard polymeric or hydrolyzed protein formulas may be used; elemental formulas should be avoided because of their high osmolarity [56]. Patients fed exclusively via the transpyloric route are at risk for deficiencies of iron, copper, zinc, and selenium because these nutrients are absorbed in the proximal gastrointestinal tract.

Short-term transpyloric feeding is given through an NJ. NJ tubes are most commonly used in the intensive care unit (ICU) setting, when feeding courses are short and patient motion is minimal. Outside of the ICU setting, NJ tubes have a number of drawbacks: They are difficult to place correctly and may require fluoroscopy to guide the tube through the pylorus and ensure appropriate tip location, with the associated risk of radiation exposure. Therefore, for patients requiring long-term administration of postpyloric feeds, surgical placement of a GJT or JT is preferable.

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Pediatric malnutrition" and "Society guideline links: Nutrition support (parenteral and enteral nutrition) in infants and children".)

SUMMARY AND RECOMMENDATIONS

- Enteral nutrition consists of providing nutrients via the gastrointestinal tract; in common usage, the term usually refers to tube feeding (rather than including oral feeds). Enteral nutrition offers several advantages over parenteral nutrition including lower costs, beneficial effects from utilization of the gastrointestinal tract, and avoidance of the many potential complications of parenteral nutrition.

- Common indications for enteral nutrition in children fall into the following categories (which are not mutually exclusive) (see 'Indications for enteral nutrition' above):

  - Impaired swallowing/oral aversion or intestinal dysfunction (eg, prematurity, cerebral palsy or other neurologic problems, or congenital anomalies of the gastrointestinal tract)

  - Excessive metabolic demands (sepsis, burns, or other type of critical illness; congenital heart disease or bronchopulmonary dysplasia)

  - Impaired absorption or digestion (short bowel syndrome, cystic fibrosis, Crohn disease, some inborn errors of metabolism, chronic renal insufficiency)

- Selection of a formula for enteral feeding depends on the patient's age, weight, degree of prematurity, ability to tolerate intact protein, and sometimes on disease-specific considerations. Separate formulas are used for infants (table 3) as compared with children (table 4A-B). (See 'Formula selection' above.)

- When initiating enteral feeds, the target volume is calculated based on estimated needs for fluids and energy. For children whose growth is within a healthy range, the recommended dietary allowance (RDA) provides an appropriate estimate of these needs, as shown in the table (table 6). These estimates are then adjusted up for children needing catch-up growth or those with a hypermetabolic disease state, or adjusted down for those who are overweight or hypometabolic. (See 'Nutritional requirements' above.)

- Patients undergoing long-term enteral feeding should be periodically reassessed by plotting serial heights and weights, and the volume of feeds should be adjusted up or down to achieve optimal growth. Serial measurements of body weight are often overlooked in critically ill patients but are important to ensure adequate nutrition for recovery and growth. (See 'Nutritional requirements' above.)

- Nutritional requirements are particularly difficult to predict in patients with certain critical illnesses, including severe burn injuries or those undergoing hematopoietic stem cell transplantation. In such cases, measurement of the resting metabolic rate by indirect calorimetry provides accurate estimate of the patient's nutritional needs and can help to avoid under- and overfeeding. (See 'Critical illness and postoperative states' above.)

- Enteral feedings can be administered via intragastric (eg, orogastric, nasogastric, or gastrostomy tubes) or transpyloric (eg, nasoduodenal, nasojejunal, or gastrojejunal) tubes. The choice depends on whether the anticipated need for enteral feeds is short or long term and whether there is an aspiration risk. Unless contraindicated by the patient's condition (eg, aspiration risk), patients requiring long-term enteral feeds should also be given some feeds by mouth to avoid development of a feeding aversion. (See 'Administration' above.)

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Topic 15643 Version 37.0

GRAPHICS

Interpretation of Z-scores for growth parameters

Z-score	Growth indicators			
	Height* for age	Weight for age	Weight for height*	BMI for age
Above 3	Very tall¶	Δ	Obese	Obese
Above 2		Δ	Overweight	Overweight
Above 1		Δ	Possible risk for overweight◇	Possible risk for overweight◇
0 (median)				
Below -1				
Below -2	Stunted§	Underweight	Wasted	Wasted
Below -3	Severely stunted§	Severely underweight¥	Severely wasted	Severely wasted

BMI: body mass index; IMCI: Integrated Management of Childhood Illness.

* Length (recumbent) is generally measured for children younger than 2 years of age, and height (standing) is measured for those 2 years and older.

¶ A child in this range is very tall. Tallness is rarely a problem, unless it is so excessive that it may indicate an endocrine disorder such as a growth hormone-producing tumor. Refer a child in this range for assessment if you suspect an endocrine disorder (eg, if parents of normal height have a child who is excessively tall for his or her age).

Δ A child whose weight-for-age falls into this range may have a growth problem, but this is better assessed from a weight-for-length/height or BMI-for-age.

◇ A plotted point above 1 shows possible risk. A trend towards the 2 Z-score line shows definite risk.

§ It is possible for a stunted or severely stunted child to become overweight.

¥ This is referred to as very low weight in IMCI training modules[1].

Reference:

1. *Integrated Management of Childhood Illness, in-service training. WHO, Geneva, 1997.*

Graphic 83941 Version 3.0

Pediatric Subjective Global Nutritional Assessment (SGNA) form

Pediatric SGNA rating form				
Consider severity and duration of changes, as well as recent progression when rating each item.				
Nutrition-focused medical history		**SGNA score**		
		Normal	**Moderate**	**Severe**
Appropriateness of current height for age (stunting)				
a. Height percentile: _____	☐ ≥3rd centile ☐ Just below 3rd centile ☐ Far below 3rd centile			
b. Appropriate considering mid-parental height*?	☐ Yes ☐ No			
c. Serial growth¶:	☐ Following centiles ☐ Moving upwards on centiles ☐ Moving downwards on centiles (gradually or quickly)			
Appropriateness of current weight for age (wasting)				
Ideal body weight = _____ kg				
Percent ideal body weight: ___ ___ ___ %	☐ >90% ☐ 75-90% ☐ <75%			
Unintentional changes in body weight				
a. Serial weight¶:	☐ Following centiles ☐ Crossed ≥1 centile upwards ☐ Crossed ≥1 centile downwards			
b. Weight loss:	☐ <5% usual body weight ☐ 5-10% usual body weight ☐ >10% usual body weight			
c. Change in past 2 weeks:	☐ No change ☐ Increased ☐ Decreased			
Adequacy of dietary intake				
a. Intake is:	☐ Adequate ☐ Inadequate - hypocaloric			

	☐ Inadequate - starvation (ie, taking little of anything)			
b. Current intake versus usual:	☐ No change ☐ Increased ☐ Decreased			
c. Duration of change:	☐ <2 weeks ☐ ≥2 weeks			
Gastrointestinal symptoms				
a.	☐ No symptoms ☐ One or more symptoms; not daily ☐ Some or all symptoms; daily			
b. Duration of symptoms:	☐ <2 weeks ☐ ≥2 weeks			
Functional capacity (nutritionally related)				
a.	☐ No impairment, energetic, able to perform age-appropriate activity ☐ Restricted in physically strenuous activity, but able to perform play and/or school activities in a light or sedentary nature; less energy; tired more often ☐ Little to no play activities, confined to bed or chair >50% of waking time; no energy; sleeps often			
b. Function in past 2 weeks:	☐ No change ☐ Increased ☐ Decreased			
Metabolic stress of disease				
☐ No stress ☐ Moderate stress[Δ] ☐ Severe stress[◊]				
Physical exam		**SGNA score**		
		Normal	**Moderate**	**Severe**
Loss of subcutaneous fat				
☐ No loss in most or all areas				

☐ Loss in some but not all areas ☐ Severe loss in most or all areas			
Muscle wasting			
☐ No wasting in most or all areas ☐ Wasting in some but not all areas ☐ Severe wasting in most or all areas			
Edema (nutrition-related)			
☐ No edema ☐ Moderate ☐ Severe			
	Normal	**Moderate**	**Severe**
Overall SGNA ranking			

Guidelines for aggregating items into global score (overall SGNA ranking):

In assigning an overall global score, consider all items in the context of each other. Give the most consideration to changes in weight gain and growth, intake, and physical signs of loss of fat or muscle mass. Use the other items to support or strengthen these ratings. Take recent changes in context with the patient's usual/chronic status. Was the patient starting off in a normal or nutritionally-compromised state?

- **Normal/well-nourished**
  - This patient is growing and gaining weight normally, has a grossly adequate intake without gastrointestinal symptoms, shows no or few physical signs of wasting, and exhibits normal functional capacity. Normal ratings in most or all categories, or significant, sustained improvement from a questionable or moderately malnourished state. It is possible to rate a patient as well-nourished in spite of some reductions in muscle mass, fat stores, weight, and intake. This is based on recent improvement in signs that are mild and inconsistent.
- **Moderately malnourished**
  - This patient has definite signs of a decrease in weight and/or growth, and intake, and may or may not have signs of diminished fat stores, muscle mass, and functional capacity. This patient is experiencing a downward trend, but started with normal nutritional status. Moderate ratings in most or all categories, with the potential to progress to a severely malnourished state.
- **Severely malnourished**
  - This patient has progressive, malnutrition with a downward trend in most or all categories. There are significant physical signs of malnutrition-loss of fat stores, muscle wasting, weight loss >10%-as well as decreased intake, excessive gastrointestinal losses and/or acute metabolic stress, and definite loss of functional capacity. Severe ratings in most or all categories with little or no sign of improvement.

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* Mid-parental height: Girls: Subtract 13 cm from father's height and average with the mother's height. Boys: Add 13 cm to the mother's height and average with the father's height. Thirteen cm is the average difference in height of women and men. For both girls and boys, 8.5 cm on either side of this calculated value (target height) represents the 3^{rd} to 97^{th} percentiles for anticipated adult height.

¶ 30% of healthy term infants cross one major percentile and 23% cross two major percentiles during the first 2 years of life, typically towards the 50^{th} percentile rather than away from it. This is normal seeking of the growth channel.

Δ Conditions causing moderate metabolic stress include routine surgery (such as small resection of bowel); laparoscopic surgery; exploratory surgery; fracture; minor infection (bronchiolitis, gastroenteritis); pressure sores or decubitus ulcers.

◇ Conditions associated with severe metabolic stress include major organ surgery (eg, stomach, liver, pancreas, lung, open chest, total cholecystectomy, or gastrointestinal pouch procedures); major bowel resection; trauma with multiple injuries, fractures or burns; multiorgan failure; severe pancreatitis, sepsis or inflammation; multiple deep pressure sores or ulcers; chronic illness with acute deterioration; current treatment for malignancy; acquired immune deficiency syndrome with a secondary infection; or hyperthyroidism.

Reproduced from: Secker DJ, Jeejeebhoy KN. How to Perform Subjective Global Nutritional Assessment in Children. J Acad Nutr Diet 2012; 112:424.

Graphic 108963 Version 3.0

STRONGkids screening tool for assessment of nutritional risk in hospitalized children

1. High risk disease (Yes = 2 points)

- Is there an underlying illness with a risk of malnutrition* or expected major surgery?
  - Subjective clinical assessment (1 point)
  - Is the patient in a poor nutritional status judged by subjective clinical assessment (diminished subcutaneous fat and/or muscle mass and/or hollow face)?

2. Nutritional intake and losses (Yes = 1 point)

- Are one of the following items present?
  - Excessive diarrhea (≥5 per day) and/or vomiting (>3 times/day) the last few days?
  - Reduced food intake during the last few days before admission (not including fasting for an elective procedure or surgery)?
  - Pre-existing dietetically advised nutritional intervention?
  - Inability to consume adequate intake because of pain?

3. Weight loss or poor weight gain? (Yes = 1 point)

- Is there weight loss or no weight gain (infants <year) during the last few weeks/months?

Interpretation: Risk for malnutrition and need for intervention (per Hulst et al, 2010)		
4 to 5 points	High risk	Consult doctor and dietician for full diagnosis and individual nutritional advice and follow-up. Start prescribing sip feeds until further diagnosis.
1 to 3 points	Medium risk	Consult doctor for full diagnosis; consider nutritional intervention with dietician. Check weight twice a week and evaluate the nutritional risk after one week.
0 points	Low risk	No intervention necessary. Check weight regularly per hospital policy, and evaluate the nutritional risk after one week.

* High risk disease includes anorexia nervosa, burns, bronchopulmonary dysplasia (maximum age two years), celiac disease, cystic fibrosis, dysmaturity/prematurity (up to corrected age six months), cardiac disease (chronic), infectious disease (eg, AIDS), inflammatory bowel disease, cancer, liver disease (chronic), kidney disease (chronic), pancreatitis, short bowel syndrome, muscle disease, metabolic disease, trauma, intellectual disability, expected major surgery, not specified (classified by doctor).

Reproduced from: Hult JM, Zwart H, Hop WC, Joosten KFM. Dutch national survey to test the STRONGkids nutritional risk screening tool in hospitalized children. Clinical Nutrition 2010; 29:106.

Graphic 110788 Version 1.0

Formula selection for infants

Indications	Formula category and description	Examples
Prematurity (For infants <34 weeks gestational age and/or weight <2 kg)	**Premature formula:** ▪ High in protein, calcium, and phosphorus ▪ Includes MCT, long-chain fat, glucose polymers, and lactose ▪ Supplemented with additional calcium, phosphorus, vitamin A, vitamin D, folate, zinc, and iron ▪ Calcium:phosphorus ratio of 2:1 ▪ Available in concentrations – 20 kcal/oz, 24 kcal/oz, 30 kcal/oz ▪ Low-iron formulations are available but are not generally recommended	▪ Enfamil Premature (20, 24, or 30 kcal/oz) ▪ Similac Special Care (20, 24, or 30 kcal/oz) ▪ Breastmilk + Human Milk Fortifier (various types)*
Premature infants, post-hospital discharge¶ (For infants with birth weight <2000 g and/or laboratory evidence of metabolic bone disease)	**Post-discharge formula:** ▪ Composition similar to above ▪ Standard concentration is 22 kcal/oz	▪ Similac Neosure ▪ Enfamil NeuroPro Enfacare
Normal gastrointestinal tract	**Standard infant formula:** ▪ Cow's milk protein ▪ Lactose ▪ Long-chain fat (vegetable oil blend); no MCT	▪ Breast milk ▪ Enfamil NeuroPro ▪ Similac Pro-Advance ▪ Gerber Good Start GentlePro
Primary or secondary lactose intolerance	**Lactose-free formula:** ▪ Milk protein isolate **or** soy protein isolate ▪ Long-chain fat ▪ Lactose free	▪ Similac Sensitive ▪ Enfamil ProSobee ▪ Similac Soy Isomil ▪ Gerber Good Start Soy
Food protein intolerance (eg, cow's milk protein intolerance)	**Hydrolysate formula:** ▪ Cow's milk protein hydrolysate ▪ Long-chain fat; variable MCT (0 to 55% of fat) ▪ Lactose free	▪ Enfamil Nutramigen with Enflora LGG ▪ Enfamil Pregestimil ▪ Similac Alimentum ▪ Gerber HA
Severe protein allergy	**Elemental formula:** ▪ Free amino acids	▪ Neocate Infant DHA & ARA ▪ Neocate Infant Syneo

	▪ Moderate MCT (approximately 30% of fat); remainder long-chain fat ▪ Lactose free	▪ Elecare Infant ▪ Puramino ▪ Alfamino Infant
Malabsorption Intractable diarrhea Steatorrhea	**Hydrolysate formula with MCT:** ▪ Cow's milk protein hydrolysate ▪ Long-chain fats; moderate to high MCT (30 to 55% of fat) ▪ Lactose free	▪ Pregestimil ▪ Similac Alimentum ▪ Gerber Extensive HA
Impaired fat absorption Chylous effusion Lymphatic disorder Metabolic disorders	**High-MCT formula:** ▪ Intact protein ▪ Very high MCT (84 to 90% of fat)	▪ Portagen ▪ Monogen ▪ Enfaport ▪ Lipistart
Decreased renal function	**Renal formula for infants:** ▪ Cow's milk protein (60% whey/40% casein) ▪ Long-chain fat ▪ Low iron ▪ Lower in potassium ▪ Lower in calcium and phosphorus (maintaining 2:1 ratio)	▪ Similac PM 60/40
Galactosemia	**Soy-based formula:** ▪ Soy-based protein ▪ Long-chain fat ▪ Lactose free (carbohydrate supplied by glucose polymers)	▪ Enfamil ProSobee ▪ Similac Isomil ▪ Gerber Good Start Soy

MCT: medium-chain triglycerides.

* For details on human milk fortifiers, refer to UpToDate content on nutritional content of human milk and fortification.

¶ Use of these nutritionally enriched formulas for preterm infants after discharge varies among institutions. For more detail, refer to UpToDate content on growth management of preterm infants and management of bone health in premature infants.

Graphic 75231 Version 12.0

Formula selection for children and adults

Indications	Formula description	Age	Examples (listed alphabetically, not comprehensive)
Intact gut	0.67 to 1.3 kcal/mL Blenderized (homogenized food) Intact carbohydrate, protein and fat Polymeric Usually isotonic Contain fiber	1-10 years	Compleat Pediatric; Compleat Pediatric Reduced Calorie; Nourish; Liquid Hope; RealFood Blends.
		>10 years (adult)	Compleat
		1-10 years	Boost Kid Essentials; Nutren Jr; PediaSure
		>10 years (adults)	Boost; Ensure; Nutren 1.0; Osmolite
Lactose intolerance	1 to 1.2 kcal/mL Intact carbohydrate, protein and fat Polymeric Most are isotonic Lactose-free	1-10 years	Boost Kid Essentials; Nutren Jr; PediaSure
		>10 years (adults)	Boost; Ensure; Nutren 1.0; Osmolite
Diarrhea, constipation, or expected long term use	1 to 1.2 kcal/mL Intact carbohydrate, protein and fat Polymeric Most are isotonic Lactose-free Contain fiber	1-10 years	Boost Kid Essentials with fiber; Nutren Jr with fiber; PediaSure with fiber
		>10 years (adults)	Boost with fiber; Ensure; Jevity; Nutren 1.0 with fiber
Increased protein needs	1 to 1.2 kcal/mL Contain approximately 30 percent more protein than standard versions Intact carbohydrate, protein and fat Polymeric Usually isotonic Lactose-free	>10 years (adults)	Boost High Protein; Ensure High Protein; IsoSource HN; Osmolite HN; Promote; Nutren Replete
	Contain fiber		FiberSource HN; Jevity Plus; Promote with fiber; Nutren Replete with fiber

Volume restriction (calorie dense)	1.5 kcal/mL May contain MCT oil May contain increased protein May have higher osmolalities Most contain intact carbohydrate and protein Polymeric Lactose free Available with and without fiber	1-10 years	Boost Kid Essentials 1.5; Pediasure 1.5
	1.5 kcal/mL	>10 years (adult)	Ensure Plus; IsoSource 1.5; Nutren 1.5; Osmolite 1.5; Jevity 1.5 (with fiber only); Glucerna 1.5
	2 kcal/mL		NovaSource Renal 2.0; Nutren 2.0; TwoCal

MCT: medium-chain triglycerides.

Graphic 53184 Version 9.0

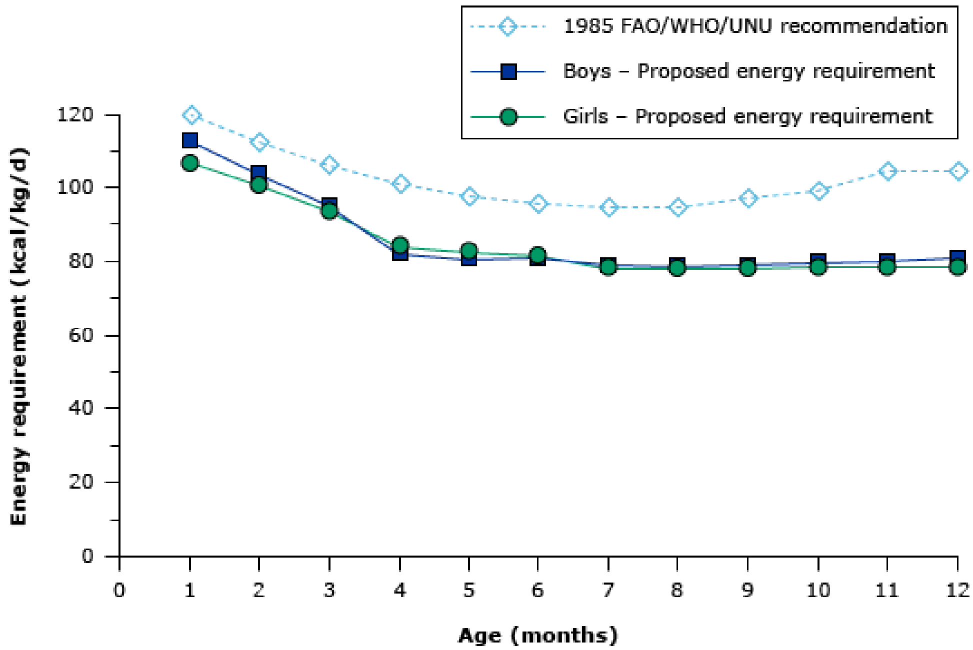
Formula selection for children and adults (continued)

Indications	Formula description	Age	Examples (listed alphabetically, not comprehensive)
Hyper-metabolism	1-1.5 kcal/mL Polymeric May have higher osmolalities May be low-fat May contain MCT May contain increased protein May contain some amino acids thought to be conditionally essential (eg, glutamine, arginine) May contain fish oil Lactose free May contain fiber	>10 years (adults)	Impact; Impact with fiber; Impact 1.5; TraumaCal
	1.0-1.5 kcal/mL Hydrolyzed protein source	1-10 years	Pepdite Jr; Peptamen Jr; Peptamen Jr 1.5; Pediasure Peptide 1.0; Pediasure Peptide 1.5
		>10 years (adults)	Crucial; Perative; Vital 1.0 cal; Vital 1.5 cal; Pivot 1.5; Optimental; Peptamen; Peptamen 1.5
Impaired digestion or impaired gut perfusion	0.8-1.0 kcal/mL Free amino acids ("elemental") May have higher osmolalities May contain MCT oil May be low fat May contain increased protein Lactose-free Most are fiber-free	1-10 years	Elecare Jr; Neocate Jr; Vivonex Pediatric; EO28 Splash
	1 kcal/mL	>10 years (adults)	Tolerex; Vivonex Plus; Vivonex TEN; Vivonex RTF

MCT: medium-chain triglycerides.

Graphic 65947 Version 5.0

Energy requirements of infants as recommended by the FAO/WHO/UNU



Energy requirements of healthy infants 0 to 12 months of age as estimated by the joint FAO/WHO/UNU Expert Consultation on Energy in Human Nutrition in 2001 (closed symbols), combining data for breastfed and formula-fed infants. The 1985 FAO/WHO/UNU estimates are shown for comparison (open symbol).

FAO: Food and Agriculture Organization of the United Nations; WHO: World Health Organization; UNU: United Nations University.

Food and Agriculture Organization of the United Nations, 2004, Human energy requirements: Report of a Joint FAO/WHO/UNU Expert Consultation. Food and Nutrition Technical Report Series 1, http://www.fao.org/docrep/007/y5686e/y5686e05.htm.

Graphic 87702 Version 2.0

Estimates of energy requirements (kcal/day) for healthy children with moderate physical activity

Age	WHO estimates* (kcal/kg/day)		IOM estimates¶ (kcal/kg/day)	
	Boys	Girls	Boys	Girls
12 months	82	80		
24 months	84	81		
3 to 4 years	80	77	104	100
4 to 5 years	77	74	97	93
5 to 6 years	74	72	90	87
6 to 7 years	73	69	84	81
7 to 8 years	71	67	80	75
8 to 9 years	69	64	75	71
9 to 10 years	67	61	71	65
10 to 11 years	65	58	67	60
11 to 12 years	62	55	63	56
12 to 13 years	60	52	60	52
13 to 14 years	58	49	57	50
14 to 15 years	56	47	55	47
15 to 16 years	53	45	54	45
16 to 17 years	52	44	52	44
17 to 18 years	50	44	50	43

WHO: World Health Organization; IOM: Institute of Medicine.

* The WHO estimates are based on assumed physical activity levels of 1.45 to 1.85 mJ/day (boys, increasing with age), and 1.4 to 1.7 mJ/day (girls, increasing with age), considered "moderate physical activity" (rather than light or vigorous physical activity).

¶ The IOM estimates for children 3 to 18 years are based on assumed physical activity coefficients of 1.6 to 1.9 mJ/day, considered "active" (rather than sedentary, low active, or very active).

References:

1. *WHO estimates from: Food and Agriculture Organization of the United Nations (FAO), World Health Organization (WHO) and United Nations University (UNU): Human Energy Requirements. Available at: http://www.fao.org/docrep/007/y5686e/y5686e00.htm#Contents (Accessed on May 16th, 2016).*
2. *IOM estimates from: DIETARY REFERENCE INTAKES FOR ENERGY, Institute of Medicine, 2005. Food and Nutrition Board, Institute of Medicine. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids (macronutrients), 2005, chapter 5. Available at: http://fnic.nal.usda.gov/dietary-guidance/dri-reports/energy-carbohydrate-fiber-fat-fatty-acids-cholesterol-protein-and-amino#overlay-context=dietary-guidance/dietary-reference-intakes/dri-reports (Accessed on January 21, 2013).*

Graphic 87722 Version 3.0

Estimated energy requirements (low to moderate activity) and recommended dietary allowance of selected nutrients for infants, children, and adolescents

Age	Energy (kcal/day)	Protein (g/day)	Total fat (g/day)	Iron (mg/day)	Calcium (mg/day)	Zinc (mg/day)
1 to 3 years						
Males	850 to 1400	13	30 to 40	7	700	3
Females	800 to 1400	13	30 to 40	7	700	3
4 to 8 years						
Males	1400 to 1900	19	25 to 35	10	1000	5
Females	1300 to 1800	19	25 to 35	10	1000	5
9 to 13 years						
Males	1800 to 2600	34	25 to 35	8	1300	8
Females	1600 to 2200	34	25 to 35	8	1300	8
14 to 18 years						
Males	2400 to 3200	52	25 to 35	11	1300	11
Females	2000 to 2300	46	25 to 35	15	1300	9

Adapted from:

1. *The Dietary Reference Intakes, National Academy of Sciences, Washington, DC, 2002.*
2. *National Academies Press. Dietary Reference Intakes for Calcium and Vitamin D (2010). Available at: books.nap.edu/openbook.php?record_id=13050&page=291. (Accessed on December 13, 2010.)*

Graphic 78274 Version 16.0

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