Transitioning the Preterm Neonate from Hospital to Home: Nutritional Discharge Criteria

By Andrea Adler, RD, CSP, LD and Sharon Groh-Wargo, PhD, RD, LD

LEARNING OBJECTIVES
After reading this article the reader will be able to:

- List potential nutrient deficits accumulated prior to discharge.
- Describe options and strategies for nutritional support at discharge.
- Identify issues related to feeding progression following discharge.

Infants born less than 37 weeks gestational age (GA) are considered premature and planning their discharge may require multiple professional teams. Criteria for discharging a preterm infant are based on physiologic parameters. These include stability (good weight gaining pattern, maintenance of body temperature, feeding without cardio-respiratory compromise), active parent involvement and medical follow-up appointments that include monitoring of growth and development.

General Information
Optimal nutrition is essential for growth and development throughout infancy and into childhood. Babies born between 34 to 37 weeks GA are considered late-preterm (“near-term”) infants. These neonates are usually able to begin enteral nutrition after birth. Infants born less than 34 weeks GA usually begin parenteral nutrition (PN) within the first 24 hours of life. Enteral nutrition is initiated and advanced based on the neonate's tolerance.

Several growth charts are used in Neonatal Intensive Care Units (NICU) and at discharge. The Fenton Growth Chart is used for preterm infants until they reach 50 weeks
Feature: Nutritional Discharge Criteria

post-conceptional age (Figure 1). Once a preterm infant reaches 40 weeks GA, the American Academy of Pediatrics (AAP) and the Center for Disease Control (CDC) recommend plotting infants on the World Health Organization (WHO) growth chart rather than the CDC’s.5 (Table 1)

The nutrition goal is to bring the nutrient status of preterm infants to normal as soon as possible.10 Nutrition recommendations for catch-up growth of preterm infants exceed those for term infants.11 There are no evidence-based recommendations on when to transition from using preterm nutrient requirements, such as the recommendations from ESPGHAN, Tsang, or the IOM nutrient requirements.7,8,9 However, it is speculated that this change should take place after 40 weeks corrected GA based on the patient’s clinical status.

Feeding Abilities
Oral-motor skills develop as the fetus grows in-utero and during the postnatal period. The majority of preterm infants are not ready to feed orally at birth. Around 34 weeks GA, suck-swallow coordination and gag mechanisms mature; however, suck-swallow-breathe coordination does not fully develop until 37 weeks GA.12,13 Infants are transitioned from gavage feedings to breast or bottle feedings in preparation for discharge. Patients may be discharged home with nasogastric feeding tubes if they are physiologically ready, but still unable to completely orally feed.1

In rare instances, a gastrostomy tube (G-tube) may be needed for an infant to be discharged home sooner. Conditions that warrant such feedings include short bowel syndrome, neurological impairment, marked oral aversion, inability to consume sufficient volume from nipple feeding or congenital anomalies.12,14 Care is taken not to overfeed via the G-tube as that may cause the device to leak formula or gastric content onto the skin.14

Human Milk/Breastfeeding
Human milk has a unique composition, helping protect against childhood obesity, Crohn’s disease, lymphoma, leukemia and diabetes.2 It also decreases the incidence of diarrhea and necrotizing enterocolitis.2,12,15 Human milk contains docosahexaenoic acid (DHA) and arachidonic acid (ARA), two long chain poly-unsaturated fatty acids that play a role in visual acuity, growth and cognitive development.2,12
As with full-term neonates, human milk offers advantages to preterm infants. Despite higher amounts of nutrients compared to term milk, preterm human milk does not contain optimal nutrition to promote growth in preterm infants. Preterm milk composition transitions to term milk composition around 4 weeks after a preterm infant is born. Cochrane Reviews report that fortifying human milk supports short-term weight gain, length and head circumference growth and possible increases in bone mineral content (BMC).

Little evidence is available to guide planning for the discharge of human-milk-fed preterm infants. O'Connor et al studied the effects of adding commercial human milk fortifier to half of human milk feeds for 12 weeks after discharge. The intervention group showed improvements over the first year of life in weight, length, BMC, and head circumference measurements, compared to the control group receiving unfortified human milk. The intervention group also showed a trend in successful completion of language and motor skills on the Bayley Index II scales. Even so, fortification did not increase percent body fat or trunk-fat mass.

On the other hand, research by Zachariasen et al showed that small amounts of fortification added to human milk until 4 months CA did not significantly affect growth at 1 year CA, compared to feeding human milk alone. However, the increased amount of protein and phosphorus improved BUN levels—a marker for protein synthesis—and serum phosphorus levels, which may potentially improve growth.

Birth weight, discharge weight, risk factors, and serum levels should all be taken into account to determine if the preterm infant at discharge can be adequately fed with human milk alone. When indicated, fortification can be added in several ways: (1) addition of commercial human milk fortifier to expressed human milk (under close medical supervision), (2) two to four feedings per day of nutrient-enriched formula along with breastfeeding or (3) addition of nutrient-enriched formula powder to expressed human milk to increase the caloric density (more accurately called ‘enrichment’).

Option one, using commercial human milk fortifier, may be indicated for extremely low–birth-weight infants who are still small at discharge, infants who have continuing medical problems such as bronchopulmonary dysplasia (BPD), and/or have BUN levels less than 9 mg/dL, alkaline phosphatase levels higher than 600 U/L or phosphorus levels less than 5 mg/dL. Option three adds energy but little additional protein or micronutrient content. Although there are currently no recommendations about fortification of human milk after discharge,

<table>
<thead>
<tr>
<th>Table 1: Description of Growth Charts³⁴⁵⁶</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Growth Chart</strong></td>
</tr>
</tbody>
</table>
| Fenton | Intrauterine growth chart (representing ideal fetal growth) and postnatal growth chart | 22–50 weeks | • More recent chart  
• Data based on meta-analysis  
• Weight is smoothed between 36–46 weeks GA; length and head circumference are smoothed at 22 weeks, to connect intrauterine growth and post term growth. | • Follow-up limited to 2 months CA  
• Does not account for initial postnatal weight loss  
• Preterm infants’ growth typically does not exceed the intrauterine growth curve  
• Anthropometrics obtained from different infants with different gestational ages. |
| Olsen | Intrauterine growth chart (representing ideal fetal growth) | 23–41 weeks | • Recent growth chart accounting for medical advances in the last 3–4 decades  
• Large, racially-diverse population from US data  
• Gender specific  
• Compares weight, length and head circumference for the same infant  
• Newer statistics for birth classification by GA (small, appropriate, or large)  
• Data validated on separate subsamples  
• Good chart for young babies at immediate post-discharge. | • May not be representative of all infants, especially of older GA, as data was obtained only on infants admitted to the NICU. |
| World Health Organization (WHO) | Postnatal growth chart (reflects initial weight loss after birth) | Term and preterm infants at 40 weeks CA-23 months of age | • Shows how children should grow for best health outcomes  
• Multi-regional data  
• Separate charts for boys and girls. | • Only used for preterm infants at 40 weeks corrected age  
• Doesn’t show “catch-up” growth. |
based on available research\textsuperscript{18,19,20} the authors recommend the following parameters for consideration of fortification after discharge. See Table 2 for a nutrient comparison of the three options.

### Infant Formulas

Preterm infant formulas (Similac\textsuperscript{®} Special Care\textsuperscript{®} or Enfamil\textsuperscript{®} Premature Formula) are recommended in the NICU if human milk is not available for infants with a birth weight <1,500g.\textsuperscript{12} These formulas are designed to meet the increased nutrient needs of premature infants and contain higher amounts of macro- and micronutrients.\textsuperscript{12, 23} As they near weights of 2,500-3,500 grams (the weight depending on the brand of formula), preterm infants must be transitioned from commercial preterm infant formulas to nutrient-enriched formulas, or the intake of Vitamins A and D will become excessive.\textsuperscript{21,22,23} Infants on commercial preterm infant formula have been shown to have a growth rate at or above intrauterine growth.\textsuperscript{23}

Nutrient-enriched infant formulas (Similac Expert Care\textsuperscript{™} NeoSure\textsuperscript{®} or Enfamil EnfaCare\textsuperscript{®}) are recommended if human milk is not available for infants with a birth weight >2,000g, or as a transition formula from the hospital to home.\textsuperscript{21,22,24} These formulas contain a nutrient composition greater than term -infant formulas but less than preterm infant formulas. Depending on birth weight, nutrient enriched formulas are recommended through 12 months corrected gestational age (CGA). Infants (especially those less than 1,250 grams at birth) on nutrient enriched formula until 9-12 months CGA show improvement in bone growth/mineralization and growth when compared to preterm infants fed standard term formula.\textsuperscript{24}

**Cochrane Reviews** evaluated seven studies of preterm infants fed either a nutrient-enriched formula or a standard term infant formula at discharge. The studies found no strong evidence that at 18 months CGA, nutrient-enriched formula supported better growth and development than standard-term formula.\textsuperscript{25} Between term and 6 months CA, preterm infants on nutrient-enriched formula may gain more lean mass and less fat mass than preterm infants fed standard-term formula.\textsuperscript{26} Regarding use of nutrient-enriched formulas, the AAP and the American College of Obstetricians and Gynecologists recommend that “Small, preterm neonates (born at or before 34 weeks of gestation, with a birth weight less than or

<table>
<thead>
<tr>
<th>Table 2: Composition of Human Milk and Formulas\textsuperscript{21,22}</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human Milk as the Base</strong></td>
</tr>
<tr>
<td><strong>Nutrient per 100 calories</strong></td>
</tr>
<tr>
<td>Energy, Cal</td>
</tr>
<tr>
<td>Protein, g</td>
</tr>
<tr>
<td>Vit A, IU</td>
</tr>
<tr>
<td>Vit D, IU</td>
</tr>
<tr>
<td>Calcium, mg</td>
</tr>
<tr>
<td>Phos, mg</td>
</tr>
<tr>
<td>Iron, mg</td>
</tr>
<tr>
<td>Zinc, mg</td>
</tr>
<tr>
<td>Mixing instructions</td>
</tr>
</tbody>
</table>

Note: Human milk is based on assumed composition of term human milk
~ indicates an average of Similac\textsuperscript{®} and Enfamil\textsuperscript{®} products; Similac\textsuperscript{®} products are made by Abbott Nutrition in Columbus, Ohio and Enfamil\textsuperscript{®} products are made by Mead Johnson Nutrition in Evansville, Illinois
Table 3: Commonly Used NICU Medications at Discharge and Nutrient Interactions

<table>
<thead>
<tr>
<th>Medication</th>
<th>Usage</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caffeine</td>
<td>Apnea of prematurity</td>
<td>May cause nausea, vomiting, GI intolerance, necrotizing enterocolitis, or GI hemorrhage.</td>
</tr>
<tr>
<td>Chlorothiazide</td>
<td>Diuretic</td>
<td>Monitor electrolytes, Ca, Phos, glucose. Delay in growth due to low serum Na, K, and Cl, which may need to be supplemented. Decreases renal excretion of Ca. Caution with Ca supplements due to an increased risk for nephrocalcinosis. May cause nausea, vomiting, constipation, or GI intolerance.</td>
</tr>
<tr>
<td>Digoxin</td>
<td>Antiarrhythmic</td>
<td>May decrease K and Mg or increase Ca and Mg. May cause feeding intolerance, nausea, vomiting, or diarrhea. Caution with calcium and vitamin D supplements.</td>
</tr>
<tr>
<td>Erythropoietin</td>
<td>Stimulates erythropoiesis</td>
<td>Increased iron needs.</td>
</tr>
<tr>
<td>Famotidine</td>
<td>H2 antagonist</td>
<td>May cause constipation, diarrhea, nausea, or vomiting. Increased risk for late-onset bacterial and fungal sepsis, however no short-term adverse effects have been seen.</td>
</tr>
<tr>
<td>Furosemide</td>
<td>Diuretic</td>
<td>Monitor serum and urine electrolytes and renal function throughout duration of usage. May cause nephrocalcinosis or nephrolithiasis. Monitor weight and fluid status. Bone demineralization may occur with long-term usage.</td>
</tr>
<tr>
<td>Metoclopramide</td>
<td>Prokinetic GI agent</td>
<td>May improve feeding intolerance. May cause increase in irritability or vomiting, nausea, diarrhea or constipation.</td>
</tr>
<tr>
<td>Phenobarbital</td>
<td>Anticonvulsant</td>
<td>May decrease serum Ca, vitamin K, vitamin B12, vitamin C, vitamin D, and folate. May cause decreased bone density. May cause nausea, vomiting, constipation, or megaloblastic anemia.</td>
</tr>
</tbody>
</table>

Ca: calcium; Cl: chloride; GI: gastrointestinal; K: potassium; Mg: magnesium; Na: sodium; Phos: phosphorous

equal to 1,800 g) and neonates with other morbidities (e.g. BPD) may benefit from the use of such formulas for up to 9 months after hospital discharge. 

Standard term infant formula can be used if human milk is not available for late-preterm (near-term) infants. Standard term formulas have compositions similar to that of term human milk. However, they are not recommended for preterm infants, even at discharge, because of their inadequate nutrient density.

Soy infant formulas are also not recommended for preterm infants. According to the 2008 AAP statement on soy infant formulas, preterm infants receiving soy infant formulas had lower serum phosphorous levels and higher alkaline phosphatase levels than preterm infants fed the standard term cow’s milk based formula. Even with calcium and Vitamin D supplementation, preterm infants fed soy formula are at risk for metabolic bone disease.

Although hydrolyzed and elemental formulas are not intended for premature infants, sometimes they are better tolerated, allowing for more rapid advancement to full enteral feeding. Hydrolyzed formulas are hypoallergenic; they reduce the risk of allergic reaction to cow’s milk protein. Elemental (amino acid-based) formulas are non-allergenic; they do not contain milk protein, fructose, galactose, lactose, gluten or soy protein. These formulas are used for severe cow’s milk protein allergy or other food protein allergies. Additional vitamin and mineral supplementation may be necessary when hydrolyzed protein or elemental formulas are fed to preterm infants.

Table 2 lists common formulas used in the NICU and at discharge, along with their nutrient composition. Refer to product handbooks for specific recipes to enrich human milk with nutrient-enriched formula or for increased caloric density formula recipes.

Vitamins and Minerals

Common supplements prescribed at discharge include Vitamin D and iron (Fe). Other supplements may also be prescribed, including calcium, phosphorous, zinc (Zn) and electrolytes. Vitamin D deficiency is a common problem across the human lifespan. In 2008, the AAP recommended supplementation of 400 International Units of vitamin D for all infants, starting within the first few days of life. Infants receiving human milk, even if supplemented with some formula, should receive a liquid multivitamin throughout the first year of life. Formula-fed infants should receive the vitamin D supplement until they consume at least 1 liter of formula a day.

The AAP recommends that preterm infants receive 2-4mg Fe/kg/day. Commercial iron-fortified formula provides 2mg Fe/kg/day and unfortified breast milk provides 0.5mg Fe/kg/day (based on the infant’s receiving 150ml/kg/day). Preterm infants receiving human milk should continue Fe supplements until weaned to formula, or are eating 2mg Fe/kg in complementary foods. Ferrous sulfate is the most effectively absorbed form of iron for the newborn.

Depending on a diagnosis of illness (i.e. metabolic bone disease), medications used at discharge, or the formula being fed, premature infants may require additional mineral supplementation. Since soy protein, hydrolyzed protein and elemental formulas are not intended for premature infants, calcium and phosphorous supplementation may be needed. Supplemental Zn may be beneficial in preterm infants receiving unfortified human milk.

Table 3 reviews the common medications that
preterm infants may receive after discharge. Table 4 lists the composition of the most common vitamin and mineral supplements.

**Nutrition Problems: Feeding intolerance**

Feeding intolerance is common in preterm infants. The most common problems include uncontrolled reflux, spit-ups and constipation. In addition, there may be medical conditions associated with feeding intolerance, such as gastroesophageal reflux disease or necrotizing enterocolitis associated with short bowel syndrome.

**Gastroesophageal Reflux**

Prematurity is a risk factor for gastroesophageal reflux (GER). GER occurs when stomach contents move up the esophagus and possibly into the mouth. In some cases, GER is a symptom of gastroesophageal reflux disease (GERD).38

Three to ten percent of premature infants weighing less than 1,500 grams have symptomatic GER.38 Positioning and dietary changes are two methods that may help treat symptomatic GER. Interventions for GER are discussed in the article entitled: “Evidence-based treatment of gastroesophageal reflux in neonates” by Susan Pfister, RN, CNRN, MA in the June 2012 issue of *Nurse Currents*.

Compared to formula feeding, human milk feeding results in shorter episodes of reflux. It is controversial if changing the type of formula or milk alters the incidence or severity of reflux.35,38 In case of GER, the type of feed may be changed for a 1-2 week trial. If no improvement is seen, the infant should be changed back to the previous formula, as appropriate for age and other clinical conditions.35,38 Small, frequent feeds decrease the incidence of reflux.35,38

Thickening the feeds with rice cereal. It is not physiologically appropriate for preterm infants, and may cause constipation.38 Commercial anti-reflux formulas that thicken upon contact with gastric contents should be used with caution, as they do not meet the nutritional requirements of premature or former premature infants.35,38 Anti-reflux formulas have been shown to reduce the amount and severity of reflux. However, the affect of the additional thickening in the anti-reflux formula may be reduced if the infant is on H2 blockers.35 In May 2011, the Food and Drug Administration (FDA) recommended that ‘Simply Thick’, a gum-based thickener, not be used in infants born premature (<37 weeks) while in the hospital and 30 days post-discharge.39

**Metabolic Bone Disease**

Preterm infants are at risk for developing metabolic bone disease (MBD), formerly known as osteopenia of prematurity. MBD is diagnosed by clinical and biochemical findings.35,36 Preterm infants miss the rapid third trimester fetal accretion of calcium and phosphorous which accounts for ~80% of the mineral stores available at term.35,36,40

If the infant with a history of MBD is discharged on unfortified human milk, serum phosphorous and alkaline phosphate should

---

**Table 4: Common Vitamin and Mineral Supplementation for Discharge**21,34

<table>
<thead>
<tr>
<th>Product</th>
<th>Enfamil® Poly-Vi-Sol® (with Fe) #</th>
<th>Enfamil® Tri-Vi-Sol® (with Fe) #</th>
<th>Enfamil® D-Vi-Sol™ #</th>
<th>Enfamil® Fer-In-Sol® #</th>
<th>AquADEKs™ *</th>
<th>Ergocalciferol **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dosage</td>
<td>1 ml</td>
<td>1 ml</td>
<td>1 ml</td>
<td>1 ml</td>
<td>1 ml</td>
<td>1 ml</td>
</tr>
<tr>
<td>Vit A</td>
<td>1500 IU</td>
<td>1500 IU</td>
<td>-</td>
<td>-</td>
<td>5751 IU (87% beta carotene)</td>
<td>-</td>
</tr>
<tr>
<td>Vit D</td>
<td>400 IU</td>
<td>400 IU</td>
<td>400 IU</td>
<td>-</td>
<td>400 IU</td>
<td>8000 IU</td>
</tr>
<tr>
<td>Vit K</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>400 mcg</td>
<td>-</td>
</tr>
<tr>
<td>Vit E</td>
<td>5 IU</td>
<td>35 IU</td>
<td>-</td>
<td>-</td>
<td>50 IU</td>
<td>-</td>
</tr>
<tr>
<td>Vit C</td>
<td>35 IU</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>45 IU</td>
<td>-</td>
</tr>
<tr>
<td>Thiamin</td>
<td>0.5 mg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.6 mg</td>
<td>-</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.6 mg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.6 mg</td>
<td>-</td>
</tr>
<tr>
<td>Biotin</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>15 mcg</td>
<td>-</td>
</tr>
<tr>
<td>Niacin</td>
<td>8 mg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6 mg</td>
<td>-</td>
</tr>
<tr>
<td>Vit B₆</td>
<td>0.4 mg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.6 mg</td>
<td>-</td>
</tr>
<tr>
<td>Vit B12</td>
<td>2 mcg (0mcg)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0 mcg</td>
<td>-</td>
</tr>
<tr>
<td>Fe</td>
<td>0 mg (10mg)</td>
<td>0 mg (10mg)</td>
<td>-</td>
<td>15mg</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Zn</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5 mg</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: # Mead Johnson Nutrition in Evansville, Indiana; listed nutrients are from elemental Fe and D3
* Yasoo Health Inc in Johnson City, Tennessee [Other brands of water-soluble vitamin supplements are available; nutrient concentrations may vary.]
** Vitamin D2 – Drisdol® by Sanofi Aventis US LLC in Bridgewater, New Jersey; Calciferol™ by Schwarz Pharma in Milwaukee, Wisconsin.
be checked at four- and eight-weeks post discharge.41 Since some infants who go home on unfortified breast milk develop MBD post-discharge, continuation of human milk fully or partially fortified with commercial human milk fortifier should be considered, especially for extremely low birth weight infants or infants with abnormal phosphorus and/or alkaline phosphatase levels.51

Commercial human milk fortifiers are difficult to obtain outside of the hospital. Infants who are provided with human milk fortifiers at hospital discharge must be closely monitored. Formula-fed infants with a history of MBD are candidates for continuation of preterm infant formula. Picaud et al found that two months after discharge, preterm infants fed commercial preterm formula had better gains in weight, head circumference, and bone mineral content (BMC) and BMD, compared to the infants fed term formula.42

Treating MBD may be accomplished in several ways. Infants who weigh <3.5kg can be discharged on human milk fortified with commercial human milk fortifier or commercial premature infant formula, and receive close monitoring/follow-up from a registered dietitian. Other options for the human milk-fed infant include alternating each feed of unfortified human milk with a feeding of a nutrient enriched formula, or enriching expressed human milk with nutrient-enriched formula powder. All of these feeding plans increase protein as well as calcium and phosphorous intake. Formula-fed infants with MBD are discharged on a commercial preterm or nutrient-enriched formula. If a soy protein, hydrolyzed protein or elemental formula is required, calcium, phosphorous, and possibly vitamin D supplementation is recommended to increase levels to the commercial preterm or nutrient-enriched formula content. Supplementation is generally continued until biochemical and radiographic findings determine healing.

Necrotizing Enterocolitis
Necrotizing enterocolitis (NEC) is a disease affecting any part of the GI tract.35 Most commonly, NEC affects the ileum, jejunum or colon.43 Twenty to forty percent of all infants with NEC will need surgery. Surgery may lead to short bowel syndrome (SBS) or, one to two months after the operation, development of strictures.49 Very low birth weight infants who survive NEC are at risk for neurodevelopmental, neurosensory and functional disabilities, as well as feeding issues (oral aversion or malabsorption).44

Initial nutrition management of a preterm infant with surgical NEC includes PN. Most infants are either transitioned off PN onto enteral feeds before discharge from the hospital, or transferred to an inpatient rehabilitation center. If human milk is not available, a hydrolyzed or elemental formula may result in better feeding tolerance than a formula with intact proteins. In any case, the choice of formula must be individualized.35,43 Preterm infants with NEC or SBS should be followed after discharge by a registered dietitian. Anthropometrics and signs of GI disturbances and nutrient deficiencies, especially if the infant was discharged home on a non-nutrient enriched formula, should be monitored.35

As with adults, preterm infants who have a bowel resection or an ostomy are at risk for nutrient deficiencies. Infants with an ostomy may require additional Na, Zn and copper supplementation.35,43 Fat-soluble vitamins need to be replaced in addition to Fe, B12, and trace elements.35,43 It is also important to monitor serum electrolytes, Ca, Phos, and Mg.35,43

Bronchopulmonary Dysplasia/Chronic Lung Disease
Bronchopulmonary dysplasia/chronic lung disease ((BPD/CLD) is a diagnosis of premature infants that has nutritional implications. BPD is defined as either an oxygen requirement for longer than 28 days of age or an oxygen requirement lasting for more than 36 weeks CGA in a baby born before 32 weeks' GA.39 Most infants with BPD/CLD are growth delayed and stunted in length when they reach 40 weeks CGA, especially if steroids were used in their treatment.45,46

Infants with BPD/CLD have increased energy expenditure, possibly due to the increased work of breathing.43 A baby may require as much as 25% more energy than basal needs. To offset this, the infant will need additional nutrients from enteral nutrition.43 Infants with BPD/CLD may need formula, concentrated to 27 calories/ounce or more, in the hospital and after discharge. It is necessary to fortify human milk or concentrate formulas to higher calories to provide appropriate micronutrient balance.35 If modular products are added, additional vitamin/mineral supplements may be needed. Infants with BPD/CLD may develop feeding aversions and may benefit from a feeding clinic (see post-discharge follow-ups).35

Growth Related Issues
It is difficult to recreate in-utero fetal growth rates in preterm infants. Accumulated postnatal growth deficits are common and these infants are often discharged home weighing significantly less than expected.15,47 Extraterine growth restriction is defined as anthropometric measurements below the tenth percentile at discharge when the patient’s anthropometric measurements at birth were greater than the tenth percentile. Poor head circumference growth by 8–months of age is associated with neurological and sensory deficits and poor school performance.47

Preterm and term infants have different anticipated growth parameters. Appropriate growth for the preterm infant between 24-40 weeks GA should be 15-20g weight/kg/day, 1.1cm length/week, and 0.5cm head circumference/week.40 Growth parameters for term newborns and former preterm infants at term CGA are listed in Table 5.48 The nutrition goal for a preterm infant after discharge is to achieve the body composition and rate of growth for a term infant at a comparable age.25

Catch up growth, an infant growing at an accelerated rate, usually occurs following hospital discharge, and may continue for the first two years of life.3,43 One author defines catch-up growth as “height velocity above normal statistical limits for age and/or maturity during a defined period of time, following a transient period of growth inhibition,” that is, occurring in both weight and length.49 Catch-up growth is usually obtained by providing appropriate nutrition so that body composition is comparable.
to that of a term infant at a comparable age. Nutrition intervention after hospital discharge is crucial to improve long-term growth and neurodevelopment. About 80% of very low birth weight and/or small for SGA infants who experience postnatal growth failure show catch-up growth by two to three years of age. Occasionally, catch-up growth may occur between eight years of age and adolescence. In rare cases little catch-up occurs and the child remains small into adulthood.

There is increasing evidence that very rapid catch-up growth may have adverse long-term effects, including increased risk for hypertension, cardiovascular disease, diabetes, and osteoporosis. Catch-up growth associated with an increase in central fat mass, but not lean mass and gains in length, leads to metabolic syndrome later in life. Once the infant is term-corrected age, it is important to monitor the weight-to-length ratio. Cooke et al showed that earlier catch-up growth was healthier and more complete when infants were fed commercial preterm infant formula until 6 months CA. These babies showed an increase in fat-free and peripheral fat mass without an increase in adiposity.

According to Lucas, “While slow growth (below the intrauterine rate) has some benefit for later cardiovascular outcome, it risks under-nutrition and its adverse consequences, and has a profound adverse effect on later cognition. Currently, the balance of risks favors the brain, and preterm infants should be fed with specialized products to support rapid growth (at least at the intrauterine rate). If there is concern for rapid weight gain on a nutrient-enriched formula, it may be diluted from the standard concentration of 22 calories/ounce to 20 calories/ounce. The lower caloric density of the nutrient enriched formula will continue to provide higher protein and micronutrient density compared to standard term formula.

Corrected Gestational Age

Preterm infants should not be expected to reach developmental milestones at the same time as term infants. Adjusting for prematurity or referring to the CGA is recommended for at least the first year, possibly up to 3½ and, in some instances, through seven years of life. Table 6 provides the equation to calculate CGA, including an example.

A preterm infant’s CGA is used to assess developmental milestones, growth, and feeding. Once a preterm infant reaches 40 weeks GA, growth can be plotted on the WHO growth chart. Developmental age is used to evaluate readiness for spoon feeding. Most authorities recommend initiating solid food from a spoon at 4-6 months CGA. Starting spoon feedings before recommended CGA may contribute to feeding problems. Introducing solid foods into the infant’s diet may decrease formula consumption and, if the solids foods are of poor nutritional quality, may compromise growth. The use of whole milk is not recommended until one year CGA.

Post-discharge Follow-Up

After discharge from the hospital, premature infants should be examined and tested to identify any medical or neurodevelopmental problems. Some follow-up clinics also monitor growth, development and nutrition. In addition to medical appointments, participation in programs offering home visiting nurses, Early Intervention, and Women, Infants, and Children (WIC) services are available. These provide support to low-income families in need of therapies, infant formulas and nutritious food.

A preterm infant should be seen within one week of discharge. NICU follow-up clinics are often multidisciplinary in nature, and frequently include dietitians. Improving the nutritional status of the preterm infant obviously minimizes adverse developmental outcomes. A dietitian should be consulted for the following: absence of catch-up growth, weight loss after hospital discharge, falling off the attained growth curve or falling below the fifth percentile on the growth chart. Follow-up by dietitians facilitates the catch-up growth of very low birth weight infants through 12 months CGA. A dietitian should see any patients who are on concentrated or specialty formulas, on PN, or who have a G-tube to assess tolerance. These infants need to be monitored for electrolyte disturbances and tolerance of formula. Where the infant is seen is also important. One study reports that infant growth parameters were significantly better at a comprehensive care (NICU follow-up) clinic than at a general practice clinic.

The infant may also need follow-up appointments with subspecialists, such as cardiologists, gastroenterologists, neurologists...

---

Table 5: Growth Parameters for Term Infants or Preterm Infants Corrected to Term

<table>
<thead>
<tr>
<th>Age</th>
<th>Weight (grams/day)</th>
<th>Length (cm/week)</th>
<th>Head Circumference (cm/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 months</td>
<td>25-35</td>
<td>2.5-3.5</td>
<td>0.5</td>
</tr>
<tr>
<td>3-6 months</td>
<td>15-21</td>
<td>1.6-2.5</td>
<td>0.5</td>
</tr>
<tr>
<td>6-12 months</td>
<td>10-13</td>
<td>1.2-1.7</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 6: Calculating Corrected Gestational Age (CGA)

(Weeks premature + weeks old) – 40 weeks = CGA in weeks
Example: An infant was born at 28 weeks GA and is now 16 weeks old. (28 weeks + 16 weeks = 4 weeks old (1 month old) CGA)

On the growth chart, this infant would be plotted at 1 month to correct for prematurity.
or surgeons, or at a multi-disciplinary infant feeding clinic. Feeding clinics often have both inpatient and outpatient programs to manage feeding disorders.

These are common in premature infants due to repeated exposure to noxious oral stimuli and the greater length of time until oral feeding skills develop. Feeding disorders usually start as a physiological problem and can then develop into a behavioral or psychological problem. Identification of the particular problem and corrective actions by a feeding clinic team have a significant impact on the growth and development of the premature infant. Left untreated, feeding problems can lead to failure to thrive, malnutrition, or impaired intellect.

Conclusion
Premature infants have higher nutritional needs than term infants. Preterm infants are at high nutritional risk following hospital discharge. Human milk is the ideal feeding after discharge but it may require fortification or enrichment to meet the nutritional needs of the preterm. Appropriate choices at discharge of the preterm include nutrient-enriched formulas, for most babies, or specialized preterm formulas, for selected babies. Routine supplementation should include vitamin D and iron. Preterm infants who are discharged without nutrient-enriched formulas may require additional vitamin and mineral supplements.

Several conditions that are diagnosed in preterm infants during the NICU hospital stay, including GER, MBD, NEC, and BPD, may be impacted by their nutrition following discharge.

About the Authors
Andrea Adler RD, CSP, LD is a neonatal dietitian at the Cleveland Clinic with 7 years of clinical experience. She is the current secretary of the Ohio Neonatal Nutritionists group. She also presents lectures about neonatal nutrition to interdisciplinary medical teams.

Sharon Groh-Wargo, PhD, RD, LD has practiced as a neonatal dietitian for more than 25 years. As a recognized expert in the field of neonatal nutrition, Dr. Groh-Wargo has written numerous publications and speaks widely on the topic of nutrition for the high-risk newborn. She is a contributor to the American Dietetic Association’s (ADA) online Pediatric Nutrition Care Manual and is an editor of the ADA’s Pocket Guide to Neonatal Nutrition.

REFERENCES
46. Atkinson S: Special nutritional needs of infants for prevention of and recovery from bronchopulmonary dysplasia J Nutr 2001; 131:942S.
51. ESPGHAN Committee on Nutrition: Feeding preterm infants after hospital discharge JPGN 2006; 42:596.