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Pediatric Malnutrition: Putting the New Definition and Standards Into Practice

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Abstract

In recent years, much effort has been directed at redefining malnutrition in the pediatric population to include the acute clinical population in addition to the more traditional ambulatory populations. In 2013, an expert panel convened to perform a critical review of available literature to craft a new approach to malnutrition. Closely thereafter, the Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition published recommended indicators for the identification and documentation of malnutrition in pediatric populations. The purpose of this article is to review the domains within the new definition of malnutrition in pediatric practice, describe populations in which the recommended indicators for identification and management are problematic in clinical practice, give case studies that apply the new definition, and finally describe the implementation of a malnutrition identification program within a large tertiary care children's hospital. (*Nutr Clin Pract*. 2015;30:609-624)

Keywords

malnutrition; pediatrics; nutrition assessment; child nutrition disorders

Malnutrition (undernutrition) is an ongoing problem among chronically ill hospitalized pediatric patients; however, it is only diagnosed in approximately 4% of patients despite prevalence rates reported between 24% and 50% worldwide.[1,2] Infants and children younger than 5 years are at greater risk due to accelerated growth velocity and brain development.[3] Identification and treatment of malnutrition are important from not only an acute standpoint but also long term as the child should be at an anabolic state consistently to achieve optimal final height and development.

Historically, the diagnosis of malnutrition has focused solely on anthropometrics for defining pediatric undernutrition. In children, the assessment of malnutrition is much more complex and involves assessing not only anthropometrics but also poor growth or stagnant growth. Children can experience many illness-related factors contributing to malnutrition such as inflammation, nutrient losses, increased energy expenditure, decreased nutrient intake, or altered nutrient utilization.[4] These confounding variables need to be considered in the assessment of pediatric malnutrition.

Pediatric malnutrition (undernutrition) in the clinical setting was recently defined by the Academy of Nutrition and Dietetics and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) as "an imbalance between nutrient requirements and intake that results in cumulative deficits of energy, protein or micronutrients that may negatively affect growth, development and other relevant outcomes."[4] This revised definition includes evaluation of patients based on 5 domains: anthropometrics, growth, chronicity, etiology, and impact on functional status (Figure 1). While the definition has assisted in the clinical diagnosis of malnutrition, there remain many gaps in the literature and challenges in everyday clinical practice in its implementation.[4,5]

Anthropometrics

Anthropometric values are used worldwide to determine nutrition status, but due to the many different growth charts used, it becomes difficult to set cutoff points internationally. Among the pediatric literature, consensus has been achieved with regard to the use of *z* scores, improving overall nutrition assessment and consistency.

In children younger than 2 years, weight, length (on a length board), and head circumference should be obtained and documented at each encounter with a healthcare provider and minimally as a part of a hospital admission assessment. In addition, this information should be plotted using the World Health Organization (WHO) growth standards to determine nutrition

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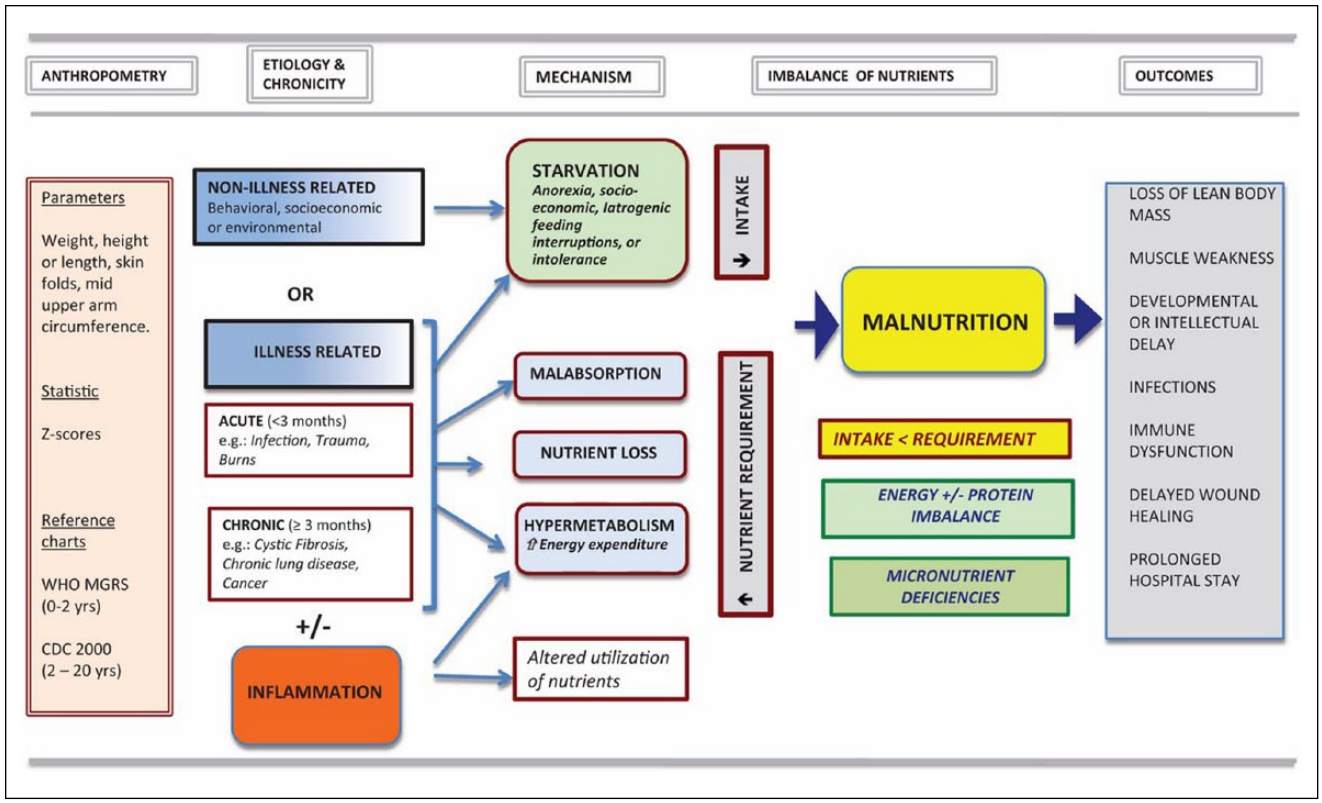

Figure 1. Defining malnutrition in hospitalized patients. Reprinted with permission from Mehta NM, Corkins MR, Lyman B, et al; American Society for Parenteral and Enteral Nutrition Board of Directors. Defining pediatric malnutrition: a paradigm shift toward etiology-related definitions. *JPEN J Parenter Enteral Nutr*. 2013;37(4):460-481. CDC, Centers for Disease Control and Prevention; MGRS, Multicenter Growth Reference Study; WHO, World Health Organization.

risk.[4] Similarly, in children older than 2 years, weight and height should be obtained and plotted using the Centers for Disease Control and Prevention (CDC) growth standard to determine nutrition risk.[4] For hospitalized children, obtaining accurate measurements of basic anthropometric values may be challenging due to clinical status and conflicting priorities.[4] When considering special populations, it is important to note the possible outcomes that may be directly correlated to anthropometrics. Specifically, Prince et al[6] described a lower mean weight for age (1.04 standard deviation [SD] below reference) upon admission to a pediatric intensive care unit (ICU) as an independent risk factor for mortality.

Height/length are the best predictors of chronic malnutrition/stunting. Stunting is defined as −2 *z* score in length/height for age. The overall surveillance of height/length is critical to accurate nutrition assessment along with routine monitoring.[4] While height/length remain important measures in the assessment of weight/length and body mass index (BMI), an accurate height/length is imperative. If a height/length are difficult to assess, proxy measurements such as knee height, tibia length, and upper-arm length have been validated specifically in the cerebral palsy population up to 12 years of age, in whom this challenge may exist.[7]

In a typical nutrition assessment, weight and height/length are the primary assessment parameters. Although these are the most validated methods, they may not always be the best methods. Mid-upper-arm circumference (MUAC) appears to be the most useful method for malnutrition assessment as it can be applied to many populations.[8] MUAC can assist when patients are fluid overloaded and wasted related to their underlying disease.[9] The use of MUAC-validated data via WHO and the United Nations International Children's Emergency Fund (UNICEF) is recommended. The current WHO guidelines for MUAC only encompass ages 6–59 months and are age and sex specific.[10] In addition to the WHO guidelines, Frisancho[11] has validated guidelines for MUAC in a broader age range (1–74 years). Although the age population is expanded, particularly for children between 5 and 19 years, the sample sizes have been limited, ranging from 155–259 per age group. In addition, *z* scores are available but may be difficult to interpret. UNICEF guidelines are based on starvation and malnutrition in developing countries and consistent with poor outcomes and mortality.[12,13] Clinical judgment is recommended in determining which MUAC reference range to use. Tricep skinfold and mid-arm muscle circumference are other tools to measure muscle mass and fat stores in pediatric patients, but from a feasibility

Table 1. *z* Score Definition Compared With Percentiles.

z Score (BMI or Weight/Length)	Growth Percentiles	Waterlow Criteria, %	Malnutrition Description
0		≥90	No risk
−1	2.4–15.9	<90	At risk/mild
−2	0.2−2.3	80−89.9	Moderate
−3	<0.2	<80	Severe

BMI, body mass index.

standpoint, it may prove difficult to implement with equipment and time required.

Given that current recommendations call for a shift from the use of percentiles to *z* scores (Table 1), it is important to have an accurate and dependable system to calculate these values. Many electronic medical records have been able to build this into their anthropometrics flowsheets and/or growth charts. In circumstances when this is not available, peditools.org is a readily available resource that accurately calculates *z* scores.

Nutrition risk screening criteria/protocols should also reflect this change.[4,5] These adjustments will likely capture a greater population of hospitalized pediatric patients compared with current benchmarked standards used in many children's hospitals.[14] In addition, *z* scores may identify more children when risk first appears vs at the time when the sequelae of malnutrition become evident. As anthropometrics are the basis of an appropriate assessment of malnutrition in pediatrics, it is imperative that the appropriate personnel (nurses, medical assistants, dietitians) are trained in proper measurement techniques, provided with ongoing education, and that instruments used are calibrated on a regular schedule to ensure accuracy.

Growth Velocity

Growth is considered the gold standard to assess nutrition status in pediatrics.[5] Change in percentiles on a growth chart is easy to assess visually. However, percentiles do not precisely capture equivocal to stagnant growth and/or weight loss. The pediatric/neonatal literature has shown outcomes worsen when a *z* score in weight-for-age decreases by 0.67.[15,16] Weight loss in conjunction with a decline in growth velocity has been identified as a component in the malnutrition criteria. Specifically, Merritt and Blackburn[17] found that 5% weight loss in 1 month is a critical threshold for an adverse clinical outcome. In addition, a 2% weight loss over a period of 1 week has been identified with malnutrition.[18] Although this is addressed in the new pediatric malnutrition assessment guidelines, additional research would be helpful in identifying the appropriate thresholds for growth changes.

The clinical practice guidelines currently address weight velocity in less than 2 years and weight loss for greater than 2 years. It may be more clinically feasible if the guidelines were similar across all age groups and to consider the use of change in weight velocity after the age of 2 years given growth potential throughout childhood.[5]

Physical Assessment

Actual physical assessment of pediatric patients is challenging given their constant growth and development. For example, what may appear to be temporal wasting may be an infant with a misshaped head. Secker and Jeejeebhoy[19] have developed general guidelines on physical assessment of children in the context of subjective global assessment. While the current guidelines lack parameters that address physical assessment, it is important for the nutrition clinician to address these factors within an assessment of malnutrition.

Chronicity

Malnutrition can be categorized into 2 main categories, acute and chronic. Both acute and chronic malnutrition occur in the pediatric population, and in some circumstances, there is overlap between the two. The classic way to distinguish between these 2 categories is based on length of time. A chronic disease is defined as lasting longer than 3 months, while acute is <3 months.[20] In many circumstances, chronic malnutrition can present in the setting of stunting vs weight loss prior to medical diagnosis.[21,22]

Etiology of Malnutrition

The etiology of malnutrition is often more than a simple lack of food. Many other factors are contributory. Most malnutrition in developed countries is due to secondary factors. Decreased nutrition intake, increased resting energy expenditure (REE), increased losses, malabsorption, infection, inflammation, and deterioration in chronic disease increase the risk of malnutrition in children. Malnutrition occurs when there is imbalance between nutrients required for normal growth and development, as well as nutrient intake.

Mechanisms Leading to Nutrient Imbalance

Decreased Intake

Accurate assessment of energy and protein needs is important to ensure adequate nutrition is provided.[23] Underfeeding and overfeeding present different problems for the chronically ill child. The gold-standard method for estimating energy needs is

Table 2. Estimated Energy and Protein Requirements for Infants Through Adolescents.[a]

Category	Age, y	Reference Weight,[b] kg	Reference Height,[b] cm	BMR (kcal/kg/d): Schofield[c]	DRI: Energy (Based on EER With PAL = Sedentary)		DRI: Protein	
					kcal/d	kcal/kg/d	g/d	g/kg/d
Infants	0–2 mo	NA	NA					1.52[d]
	2–3 mo	6	62	54	**609**	102	9.1	1.52[d]
	4–6 mo	6	62	54	**490**	82	9.1	1.52[d]
	7–12 mo	9	71	51	**723**	80	11	1.2[e]
	13–35 mo	12	86	56	**988**	82	13	1.08[e]
Boys	3 y	12	86	57	**1020**	85	13	1.08[e]
	4–5 y	20	115	48	**1402**	70	19	0.95[e]
	6–7 y	20	115	48	**1279**	64	19	0.95[e]
	8 y	20	115	48	**1186**	59	19	0.95[e]
Girls	3 y	12	86	55	**986**	82	13	1.08[e]
	4–5 y	20	115	45	**1291**	65	19	0.95[e]
	6–7 y	20	115	45	**1229**	61	19	0.95[e]
	8 y	20	115	45	**1183**	59	19	0.95[e]
Boys	9–11 y	36	144	36	**1756**	49	34	0.94[e]
	12–13 y	36	144	36	**1599**	44	34	0.94[e]
	14–16 y	61	174	28	**2385**	39	52	0.85[e]
	17–18 y	61	174	28	**2230**	37	52	0.85[e]
	>18 y	70	177	28	**2550**	36	56	0.8[e]
Girls	9–11 y	37	144	32	**1567**	42	34	0.92[e]
	12–13 y	37	144	32	**1490**	40	34	0.92[e]
	14–16 y	54	163	26	**1760**	33	46	0.85[e]
	17–18 y	54	163	26	**1684**	31	46	0.85[e]
	>18 y	57	163	23	**1939**	34	46	0.8[e]

[a]This table is meant to be a quick reference guideline as calculations are based on reference heights and weights. Various sources present age groups differently; therefore, some calculations reflect the average between sexes and age groups. Bolded items represent DRI: energy (based on EER with PAL = sedentary). BMR, basal metabolic rate; DRI, Dietary Reference Intake; EER, estimated energy requirement; NA, not applicable; PAL, physical activity level. Source: *Texas Children's Hospital Pediatric Nutrition Reference Guide*, 10th ed., 2013. Used with permission.
[b]Reference weights and heights taken from Institute of Medicine. *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements Divided Into Smaller Groupings*. Washington, DC: Institute of Medicine; 2006.
[c]Estimates based on Schofield equations for calculating basal metabolic rate in children.
[d]Adequate intake.
[e]Recommended dietary allowance.

indirect calorimetry, and this method should be employed when available. However, since it is not consistently available, equations such as Schofield, WHO, Dietary Reference Intake (DRI), and REE must be used to estimate needs (Table 2).[5,24] Because equations tend to underestimate or overestimate energy needs, nutrition needs and response to nutrition therapy must be assessed frequently.

Providing adequate nutrition is shown to improve overall outcomes in critically ill ventilated children. Mehta et al[25] found that increasing energy intake from 33% of prescribed energy to 66% significantly decreased the risk of mortality. Other improved outcomes included lower infection rate, decreased length of stay, decreased duration of ventilation, positive or stable anthropometric trends, and decreased morbidities due to chronic disease. Decreased nutrient intake over a long period of time may lead to micronutrient deficiencies if not properly monitored and supplemented. The literature is lacking in assessment of intake, but Sermet-Gaudelus et al[18] found that intake less than 50% of estimated energy needs over a 48-hour time period leads to poor outcomes.

It is important to note various factors contribute to poor intake and should be considered in the assessment process. Dietary and fluid restrictions, early satiety, anorexia of disease, gastrointestinal (GI) symptoms, delayed oral motor skills, and medications are some of the factors. Coupled with other risk factors for malnutrition, poor dietary intake can result in poor growth. Due to the variability of assessing dietary intake and the feasibility for 100% accuracy in a hospitalized patient, clinicians are urged to look at intake data in the context of physical findings and clinical situation to determine adequacy of nutrition provided.

Excessive Losses

Vomiting and diarrhea. According to the WHO, diarrhea accounts for approximately 10% of deaths in children younger

than 5 years globally and is the leading cause of malnutrition in children.[26] The incidence of vomiting and diarrhea is higher in malnourished patients. Hecht et al[27] reported that 26% of malnourished patients experienced vomiting compared with only 14% of well-nourished patients ($P < .001$), and diarrhea occurred in 22% of malnourished and 12% of well-nourished children ($P < .001$). Longer periods of vomiting in malnourished children (2 days vs 1 day, $P = .006$) were also reported. Vomiting and diarrhea, if prolonged, also contribute to micronutrient deficiencies.

Sodium Wasting Disorders

Preterm and low-birth-weight infants are known to have high renal and intestinal sodium losses during the first few weeks of life. Studies have shown that failure to provide adequate sodium supplementation during this critical time can be detrimental to the long-term neurodevelopment of the child.[28]

Sodium wasting disorders occur due to cerebral and kidney dysfunction. One of the kidney's primary functions is to maintain sodium and fluid homeostasis. When this process is disrupted in patients with dysplasia or obstructive uropathy, sodium and fluid losses lead to intravascular volume depletion and negative sodium balance. If uncorrected, poor growth will follow. Parekh et al[29] described improved growth in children who were appropriately supplemented with sodium and fluid.

Increased requirements/hypermetabolism/catabolism. An increase in physical activity not necessarily from exercise may induce increased energy needs. For example, seizures and dysautonomia may increase needs.[23] In congenital heart disease (CHD), an increase in REE is related to cardiac failure, infections, increased work of the heart, increased basal temperature, and increased activity of the nervous system.[30] Similarly, increased work of breathing in patients with pulmonary dysfunction results in higher metabolic rates.[31]

Optimal nutrition is important in conserving or restoring body mass. Catabolism involves the breakdown of lean body mass and, without adequate protein intake, will escalate the problem by promoting negative nitrogen balance. Children who are admitted to the hospital with malnutrition have little reserves, making adequate nutrition essential to care. Adult studies show that inadequate protein intake in the critically ill will hinder overall outcomes.[32] Children have higher protein needs compared with adults, even when healthy. This illustrates how vulnerable children are to suboptimal protein intake.

The literature on pressure ulcers in children is less publicized compared with adults. However, it does suggest that pediatric patients are at risk and should be assessed regularly. One of the major risk factors for the development of pressure ulcers is inadequate nutrition.[33] Children with open wounds have higher nutrient needs, specifically protein, zinc, ascorbic acid, and vitamin A, to promote healing. Severe burns trigger a hypermetabolic state; therefore, even with adequate calories and protein, growth retardation occurs acutely and chronically.[34]

Altered Utilization/Malabsorption

Acidosis. Metabolic acidosis occurs when there is a shortage of bicarbonate, and acid-base homeostasis is disrupted or there is an overproduction of acid in the body.[35] Acute acidosis typically occurs in critically ill patients and can lead to cardiovascular problems, including hypotension, decreased immune function, and increased inflammation. Chronic acidosis causes muscle wasting, poor growth, and hypoalbuminemia. Acidosis is a major cause of muscle wasting in chronic kidney disease (CKD), while correction of acidosis is associated with improved muscle mass and protein balance.[36]

Fat malabsorption. Malabsorption of fat and fat-soluble vitamins occurs predominantly in patients with liver disease, cystic fibrosis (CF), and intestinal failure. Patients with CF experience a lower pH in the duodenum due to inadequate pancreatic bicarbonate secretions. A normal pH level is required for fat digestion and absorption; hence, a lower pH level, as seen in patients with CF, is a cause of fat malabsorption. The reduction of available bile salts to solubilize fat due to fecal bile salt losses also contributes to poor fat absorption. In patients with intestinal failure, the presence of a lower surface area for fat-soluble vitamins increases the risk of poor absorption and deficiencies. Yang et al[37] found that even when supplements were provided to patients with intestinal failure, micronutrient deficiencies were still present. Although patients with malabsorption may not have a higher REE than a healthy child, increased calories may need to be provided to account for the losses. The use of medium-chain triglycerides and micronutrient supplementation are typically required when fat malabsorption is present. Calcium, magnesium, zinc, and vitamin D deficiencies have been reported in patients with fat malabsorption. Higher dose supplementation may be required to offset losses.[38] Biochemical analysis of micronutrients must be performed to accurately assess status, not just assessment of intake.

Carbohydrate malabsorption. Carbohydrate malabsorption is associated with increased GI symptoms such as diarrhea, flatulence, and bloating. Carbohydrate malabsorptive disorders include fructose malabsorption, lactose intolerance, and small bowel disease. Small bowel disease can cause diarrhea and lead to malabsorption.[39] Weight loss, steatorrhea, and nutrient deficiencies are observed as well. Common deficiencies reported in the literature are iron, folic acid, vitamin B_{12}, fat-soluble vitamins, zinc, and copper.[40]

Another element to consider in malabsorption is drug-induced enteropathy.[39,41] When duodenal villous atrophy is present, malabsorption and diarrhea typically occur. Mycophenolate mofetil is a drug commonly used in transplant patients to prevent rejection. However, side effects include diarrhea, weight loss, and malabsorption. The mechanism is not completely known but thought to cause duodenal villi apoptosis.

Inflammation. Patients with inflammatory diseases are known to have growth retardation caused by chronic inflammation.[42–45] Some studies report a higher REE likely related to inflammatory status. Diseases such as inflammatory bowel disease (IBD), CKD, and rheumatologic diseases increase the risk of malnutrition and growth retardation due to the chronic exposure to circulating proinflammatory cytokines. These cytokines include tumor necrosis factor α (TNFα), interleukin 6 (IL-6), interleukin 1β (IL-1β), and interleukin 1 (IL-1). These cytokines act both directly and indirectly on the growth plate to suppress longitudinal bone growth by decreasing chondrocyte proliferation and hypertrophy, as well as increasing apoptosis. Most patients with inflammatory disease have normal growth hormone levels but decreased insulin-like growth factor 1 (IGF-1) levels. Malnutrition also contributes to decreased IGF-1 levels by decreasing liver production of IGF-1, further escalating the problem. Many patients with inflammatory diseases are treated with glucocorticoids as anti-inflammatory therapy, but glucocorticoids also cause growth retardation. Most feel the best therapy to improve growth is to control inflammation with decreased exposure to glucocorticoids.[45]

Of patients with IBD, 10%–35% have height stunting. IBD tends to manifest just before puberty, a time when 15%–20% of adult height is achieved, making it highly certain that patients will experience a decrease in adult height. An estimated 40% of height stunting is directly related to inflammation in rat models.[21] Height velocity is typically decreased before weight loss occurs in Crohn's disease. Reduced food intake due to GI symptoms, cytokine activity, increased fecal losses, malabsorption, and protein-losing enteropathy all contribute to malnutrition in these patients. Nutrition supplementation is typically inevitable to maintain adequate nutrient intake.[46]

Elevated inflammatory markers have been reported in CKD/end-stage renal disease (ESRD) and thought to contribute to malnutrition. Canpolat et al[47] reported a significant elevation of IL-6 as an independent predictor of decreased fat stores in pediatric hemodialysis patients. However, other pediatric studies[48] do not have the same findings, leaving it unclear whether inflammation contributes to malnutrition in children with kidney disease. Another factor that must be considered are high cytokine levels, which have been found to reduce appetite and increase satiety by acting on the hypothalamus.[36]

Dysbiosis or an altered gut microbiome is an additional factor to consider as etiologies of malnutrition. However, the reverse, malnutrition leading to dysbiosis, may occur as well. Studies of this phenomenon have mostly been conducted in developing countries. Exposure to various bacteria through diet to build a healthy microbiota is important to prevent a vicious cycle of events such as infection, inflammation, altered absorption, and decreased immune function. The microbiota's function to the immune system is to enhance epithelial cell development and provide a barrier to toxins to enable better nutrient absorption. Although this is more of a concern in developing countries, patients at risk for malnutrition in these areas may experience dysbiosis due to chronic infections and decreased nutrient absorption, leading to malnutrition and, hence, an altered microbiota.[49]

More research is needed on the mechanism of inflammation on growth. However, most agree that control of inflammation/disease and provision of adequate nutrition support are important in reducing growth failure in patients with chronic inflammation. The factors discussed above should be considered in the overall malnutrition assessment. The nutrition clinician should be able to identify the factors present based on the clinical condition and information available. Multiple factors may contribute to a worse prognosis or a more rapid decline in nutrition status.

Functional Assessment

Physical Function

Evidence is well documented regarding the impact of malnutrition and its resultant changes in functional outcomes. Functional status changes in the setting of a pediatric patient can be inclusive of changes in muscle strength, loss of or delayed development either physically or cognitively, increased infections or immune dysfunction, extended hospital stays, and delayed healing.[4,27,50] There are a variety of methods to assessing functional status, but gold standards are not readily available for their use due to cost, time, or ease of use. Nutrition clinicians should use all measures available to aid with an assessment of functional status that can also be trended over time and considered indicative of worsening nutrition status or malnutrition.

Diminished muscle strength via muscle atrophy or low muscle reserve is well documented in malnutrition.[50–52] Handgrip strength has been proposed as an easy, reliable measure of muscle strength, with limited but strong evidence in pediatrics to support its use. Grip strength is strongly correlated with weight and height as well as fat-free mass in children and adolescents.[53–55] In a study by Silva et al[56] on children 6–18 years of age, BMI *z* score was significantly associated with handgrip strength whereby, as *z* score decreased, so did handgrip strength. Interestingly, Alvares-da-Silva and da Dilveria[51] found that malnutrition prevalence rates were higher in adult cirrhotic outpatients as measured by handgrip strength and shown to have a more predictive value than other nutrition assessment techniques in predicting major complications over a 1-year period.

Normative age-specific values for handgrip strength in healthy 6- to 18-year-olds are available and allow for observation of development and evaluation of therapeutic interventions over time.[54,55] Given the presentation of a grip strength growth curve, it could be theorized that a practitioner may be able to differentiate the degree of low muscle reserve or strength loss and thus define the degree of malnutrition. Still, further research is needed to establish larger population-based reference curves for handgrip strength.

Another increasingly studied measure of functional status in pediatrics that may have similar ease of use is the 6-minute walk test (6MWT). Bosa and colleagues[52] showed that the 6MWT was significantly associated with malnutrition and low muscle reserves. This has been used in adults to measure submaximal level of functional exercise capacity. Geiger et al[57] worked to establish reference values and equations for children, but the sample size of 528 poses a concern. More research is warranted in developing age-based reference curves with larger sample sizes to make this more applicable in clinical practice.

The use of handgrip strength and the 6MWT in assessing muscle strength and functional capacity may be variable depending on practitioner accessibility to equipment (a dynamometer) or someone who is trained to administer the test. It would be feasible for nutrition clinicians to be trained on how to perform these tests. Future research recommendations would suggest easy pictorial screening or simple screening questionnaires that might elucidate changes in muscle strength with more ease. An example could be the clinical frailty scale, a 9-point descriptive and pictorial tool that has been highly correlated with the frailty index and is predictive of measures of cognition, function, or comorbidity in assessing risk for death.[58,59] Although frailty is primarily studied in adults and elderly individuals, study measures of frailty mimic those of malnutrition diagnoses. In addition, children with chronic disease are more likely to show signs of accelerated aging, even in young adulthood. A study by Ness et al[60] looked at physiologic frailty in adult childhood cancer survivors and found that the prevalence of frailty among this young adult population was similar to adults 65 years or older. It could be theorized that this would likely occur before individuals even reach young adulthood and may occur with many other types of chronic illnesses that affect pediatrics.

In addition to direct markers of muscle strength such as handgrip strength, another widely studied functional test is spirometry to assess lung function and thus functional status. As muscle loss or low muscle reserve occurs in malnutrition, the muscles used for respiration can also experience decline. Most notably, pulmonary function tests have shown significant correlation with nutrition status in pulmonary diseases such as cystic fibrosis.[61] Paglialonga et al[62] found positive correlations with body weight and spirometric parameters in children on maintenance hemodialysis, and Ziora et al[63] found strong positive correlations between weight and absolute values of spirometric parameters in adolescents with anorexia nervosa. Functional assessments and tests should also be directed based on the individual condition or illness. Spirometry may not be applicable in all situations or chronic illnesses but may provide another measure to trend and assess in a patient's entire picture, especially those with pulmonary disease. In children with CHD, a measure that has been associated with nutrition status is B-type natriuretic peptide (BNP), a measure of excessive myocardial stretching. Radman et al[64] found an inverse correlation between total body fat mass and BNP levels, whereby lower total body fat mass and malnutrition were also associated with worse clinical outcomes. Last, it is important to remember the basic physiologic effects of severe acute malnutrition such as bradycardia, hypotension, hypothermia, and postural orthostatic tachycardia syndrome as frequently seen in severe eating disorders.[65] These basic measures could also be included in an assessment of functional status.

There is also the question as to when to measure physical function and at what frequency. The answer could reflect immobility over time. In healthy individuals, for every week of immobilization, the rate of muscle mass loss is 4%–5%.[66] Van Mook and colleagues[67] found that 100% of patients with multiorgan failure and up to 80% of patients mechanically ventilated >7 days developed muscle atrophy. Frequent or, at a minimum, weekly monitoring of functional status may be prudent for individuals who are identified as being immobile for an extended period of time or those with extended hospital length of stay.

Immune Function

Mehta et al[4] described immune deficiency as another functional outcome that can be monitored in malnourished children. Malnutrition impairs immune function and the GI barrier, thereby increasing infection risk and severity.[68] The in-depth review by Raiten and colleagues[68] of the relationship between nutrition and inflammation described the interaction between malnutrition and immune function as bidirectional. In addition to protein-energy malnutrition, key nutrients have been frequently studied in a variety of models and their impact of deficiency on both innate and adaptive immunity. Some of these include vitamin A, zinc, iron, and, more recently, vitamin D.[68,69]

Vitamin A deficiency is associated with decreased epithelial barrier function and an increased risk in mortality from infectious disease.[68,70] Zinc deficiency is also associated with decreased epithelial barrier function as well as growth retardation, poor cognitive development, delayed sexual maturation, and skin lesions. Iron deficiency can lead to cognitive and motor development deficits, especially if deficiency is long term. Lower levels of vitamin D have been associated with higher risk of respiratory tract infections in newborns,[71] urinary tract infections in children,[72] and an increased risk factor for sepsis and mortality in critically ill patients.[73]

Decreased immunity may be difficult to quantify patient to patient, and its severity and impact would likely vary based on illness. Routine monitoring of these micronutrient deficiencies may be able to act as surrogate functional markers of immune deficiency in the presence of malnutrition. It may provide some means of quantifying the degree of malnutrition from an immune deficiency standpoint. It is important to note that the presence of inflammation and its acute phase reactants will alter micronutrient status indicators such as increasing ferritin and decreasing transferrin, serum iron, zinc, and retinol.[69] Therefore, more research is needed in the identification of micronutrient status indicators in the setting of inflammation.

Cognitive Function

Mehta et al[4] suggest developmental assessment and neurocognitive monitoring as a functional outcome of malnutrition. The evidence is quite robust to support this recommendation. The meta-analysis of child development and linear growth by Sudfeld et al[22] found that every unit increase in height-for-age *z* score in children younger than 2 years was associated with a 0.22-SD increase in cognition at 5–11 years. The investigation by Dykman et al[74] concluded that school-aged children who were formerly defined as failure to thrive had lower intelligence quotients (IQs) and clinically adverse attention and aggression ratings. Sudfeld and associates[22] even suggest that due to its robust relationship, restricted growth and stunting could be used as an incomplete proxy for developmental delay. Neurocognitive testing is the gold standard for monitoring development and cognition; however, this is a test that, practically speaking, is not easily administered and is only done when significant concerns are raised. It is likely many patients will not have baseline neurocognitive testing done. Without the presence of readily available information to assess, nutrition clinicians may be limited to simply monitoring for loss of developmental milestones and cognition or inability to perform previous tasks. Health-related quality-of-life measures are quantifiable and objective measures that clinicians may have more access to at baseline and follow-up monitoring, especially in the chronic disease setting. A health-related quality-of-life measure measures not only physical dimensions via health and functional status but also psychosocial dimensions of emotional and role functioning.[75] The Pediatric Quality of Life Inventory (PedsQL) is a validated tool and has a minimal clinically important difference cutoff within each domain that, by definition, could support a change in the patient's management.[76] It has been studied across a variety of pediatric chronic conditions where research has also indicated that there are substantial differences on impact of specific chronic diseases.[76] The relationship between quality of life and malnutrition has also been clearly documented in the research.[27,77] In adult dialysis patients, higher malnutrition-inflammation scores were associated with not only 5-year mortality but also poorer health-related quality of life across all scales and dimensions.[78] Samson-Fang et al[79] reported that malnutrition was associated with decreased participation in usual activities of both child and parent. In children with cancer, Brinksma and colleagues[80] found undernourished children had lower quality-of-life scores reported. In addition, they found that for those with a weight loss of more than 0.5 SD, total PedsQL score was significantly lower.

As presented above, it is becoming more evident that these measures of functional status are intimately related to one another. Teixeria et al[81] found that the 6MWT performed on children and adolescents with CKD showed a significant positive correlation with height, PedsQL score, and pulmonary function tests. Any number of functional tests are relevant to assessing children's level of malnutrition. It is important to note that any functional test may also have different expected disease norms. In addition, it is clear more research is needed in pediatrics. A suggestion for future research would be the inclusion of a validated screening tool to quickly and easily identify changes or lack of progress in both physical function and cognition.

Special Population Considerations

Through application of the malnutrition assessment described by Mehta et al[4] and Becker et al,[5] nutrition practitioners are likely to come across populations that are difficult to apply these recommendations and techniques.

Patients With Chronic Illness–Related Height Stunting

Although growth failure can clearly be indicative of malnutrition, there are some situations in which chronic illness or the treatment thereof is the causative agent in growth failure. Thus, labeling these children malnourished simply due to stunting is not necessarily accurate. In practice, providing additional nutrition support would likely not improve linear growth and may put them at risk for excess fat accumulation. Some factors to consider are corticosteroid exposure, radiation exposure, chronic inflammation, and CKD.

Corticosteroid exposure has been shown to be negatively associated with post–solid organ transplant linear growth.[82–85] Chronic corticosteroid use is not limited to solid organ transplant recipients. A review of inhaled corticosteroids in children with persistent asthma by Zhang and colleagues[86] found that these children exhibited a mean decrease of 0.48 cm per year in linear growth. Bakker et al[87] reported that total-body irradiation and hematopoietic stem cell transplantation led to a reduction in height SD score by 1.1 in girls and 1.7 in boys. Chronic inflammation and its proinflammatory cytokines are thought to alter the neuroendocrine axis and may exert additional independent effects on growth without regard to nutrition status as described in children with inflammatory bowel disease.[68,88] Growth failure in children with CKD is quite prominent and also can be independent of nutrition status due to both chronic inflammatory processes as well as alterations in growth hormone metabolism and cellular resistance to growth hormone.[89]

An approach that should be considered in the case of assessing malnutrition and chronic illness–related stunting may be to adjust BMI/age *z* scores based on the child's height/age *z* score at point zero. This may prevent placing those at risk for excess fat accumulation in the correct scenario. This is by no means a new suggestion, as these recommendations are very similar to those given by Kidney Dialysis Outcomes Quality Initiative (KDOQI) Children With CKD Work Group, where it is suggested that expressing BMI relative to height-age can minimize errors of malnutrition assessment in this selected patient population. One would need to consider the appropriateness of this method in conjunction with assessment of the child's bone age and Tanner staging as caution is warranted in relating this

to children outside the pubertal period where the association between height-age and maturation is reportedly less clear.[90]

Patients With CF

Individuals with CF have high prevalence rates for malnutrition due to the multifactorial nature of the nutrition effects as well as the rapid progressive nature of weight loss in disease deterioration. As clinicians caring for patients with CF, one would likely question how recent recommendations can apply to these patients given their high degree of nutrition risk. The Cystic Fibrosis Foundation (CFF) has established growth guidelines for children older than 2 years to attain and maintain, at minimum, a goal BMI of greater than the 50th percentile for age (*z* score 0) on CDC growth charts. For children younger than 2 years, with the use of WHO growth charts, the weight-for-length goal for children younger than 12 months remains greater than the 50th percentile but, between 12 and 24 months of age, recommends a weight-for-length goal of greater than the 75th percentile. Additional recommendations include the monitoring of goal weight-for-age cutoffs that fluctuate between birth and 24 months as well as appropriate growth velocity goals depending on level of risk. Specifically, in those patients with a BMI percentile greater than 50th, the minimum growth velocity goal should be greater than the 10th percentile (between −1 and −2 *z* score), and for those with a BMI percentile less than the 50th, the minimum growth velocity should be at the 50th percentile or greater (>0 *z* score). These data are all based on the fact that patients who meet these goals have improved pulmonary function and survival rates.[91–93]

Theoretically, a nutrition clinician may have a patient with CF who falls at the 25th percentile, above the −1 *z* score BMI/age cutoffs with a zero *z* score (50th percentile) of growth velocity that would not necessarily be termed malnourished by anthropometric criteria alone. By CFF guidelines, this patient is not meeting goals. Unfortunately, the CFF does not stratify degree of risk below the 50th percentile. However, practically speaking, many CF centers run on nutrition algorithms to quickly identify and aggressively treat patients not meeting goals, whereby the patient described above may be considered for gastrostomy tube placement. In this instance, one may consider the level of intervention equivalent to the level of malnutrition. When looking deeper at the anthropometric cutoffs given by Becker et al,[5] it may be contemplated that for patients with CF, higher BMI/age and weight-for-length *z* score cutoffs as well as higher growth velocity/weight loss cutoffs should be explored and considered. The use of both functional assessment and physical assessments of fat and muscle losses would be paramount to define the degree of malnutrition in a patient with CF who experiences decreases in pulmonary function tests and disease deterioration.

Patients With Eating Disorders

Children and adolescents with eating disorders represent a unique population of starvation-based malnutrition. However, nutrition clinicians might consider eating disorders as an illness-related form of malnutrition for a variety of reasons. The prevalence rate of children with disordered eating patterns is approximately 5% among adolescent females. It is a mental illness with frequent relapses of up to 30% in anorexics.[94] Approximately 20% of those with anorexia nervosa and 10% of those with bulimia nervosa continue to meet criteria into long-term follow-up.[95,96] In addition, a number of GI disturbances may perpetuate the disease.

Children with bulimia nervosa may not meet anthropometric *z* score criteria for malnutrition, but as research shows, these individuals are usually overweight or within 10% of their ideal body weight and can have metabolic consequences that are life threatening. In addition, intake may also be very difficult to assess in a situation where you have a patient exhibiting binge/purge behaviors. The definition of malnutrition in a child with disordered eating behavior should rely heavily on physical assessment of muscle and fat loss as well as functional assessments encompassing loss of strength but also of physiologic instability signs such as bradycardia, hypotension, hypothermia, and postural orthostatic tachycardia syndrome.[65,95,96]

Neonates and Premature Infants

Neonates and premature infants represent another possible gap in a unifying method of diagnosing malnutrition. The primary concern is the natural course of weight velocity immediately after birth, when it is known that infants will experience weight loss and may take approximately 2 weeks to regain birth weight. When it comes to premature infants, there are no weight-for-length *z* score charts to define malnutrition anthropometrically. In addition, terms such as *small-for-gestational age* (SGA) and *intrauterine growth retardation* raise concerns for fetal malnutrition in neonates and premature infants. However, as Metcoff[97] explains, these terms are not synonymous with each other, and the presence of one or both does not indicate the presence of fetal malnutrition. In a study of 1382 neonates, Metcoff determined that 10.9% had fetal malnutrition, which included 5.5% of appropriate-for-gestational age (AGA) infants and 54% of SGA infants.

Metcoff[97] examined a scoring system based on clinical evidence of malnutrition and physical assessment of muscle and fat losses (also known as the CANSCORE). Metcoff describes the skin of infants with fetal malnutrition as loose or too large around the arms, legs, elbows, knees, and interscapular regions while the fat pads around the buccal and buttock regions appear decreased. If the infant is severely malnourished, he or she will exhibit an emaciated or marasmic appearance. Adebami and Owa[98] also studied the CANSCORE as an early detection method for malnutrition in newborns and found that it was able to diagnose malnutrition more precisely than SGA. Their study of 442 term infants found that 49.4% of infants would not have been termed *malnourished* using intrauterine growth standards alone, while 61.4% of infants would not have been

Table 3. Case Study 1.

Assessment Criteria	Assessment Detail
Clinical presentation	4-month-old male with fever and increased fussiness
Diagnosis	CF: diagnosed at 4 weeks of age with pancreatic insufficiency and multiple admits for pulmonary exacerbations
Anthropometrics	Weight: 4.8 kg (*z* score: −1.46)
	Height: 59 cm (*z* score: −0.51)
	FOC: 39 cm (*z* score: −2.02)
	Weight-for-length: 2% (*z* = −2.02) based on WHO 0−36 months weight-for-length data
	IBW: 5.63 kg (85% IBW) (based on WHO 0–36 months weight-for-length at 50th percentile)
	Nutrition status: high nutrition risk status, per CF Foundation guidelines
	Growth velocity: +245 g since clinic visit (+49 g/d; goal = 23–34 g/d)
Food and nutrition-related history	Semi-elemental formula: 24 calories per ounce, 4 ounces every 2–3 hours (140 kcal/kg, 4 g/kg protein)
	Appetite slightly decreased when the fever started but overall eating well
	Vitamins/minerals/herbal products: fat-soluble multivitamin 1 mL/d in bottle, salt 1/8 teaspoon/d in bottle
	Pancreatic enzymes: 3 caps with feeds provides 1875 units lipase/kg/meal; patient takes enzymes from a spoon
Physical assessment	Overall appearance: small for age, thin extremities
	Digestive system: runny stools/greasy (3–4 times/d). No emesis or spit-ups reported per mom.
	Oral-motor skills: intact with no deficits identified; taking enzymes off spoon with applesauce
Clinical data	White blood cell count: normal
	25-Hydroxyvitamin D: low
	Pancreatic elastase: low (pancreatic insufficiency)
	No pulmonary function test as patient is younger than 5 years
Functional status	Unable to accurately assess functional status as infant is 4 months of age
Overall nutrition status	**Illness-related acute moderate malnutrition**
	Anthropometrics
	Weight-for-length *z* score: −2.02
	Weight gain velocity meets age-expected weight gain
	Physical assessment
	Thin cheeks and chin. Limited fat mass on limbs.
	Etiology
	+ malabsorption given loose stools
	+ possible inflammation and/or hypermetabolism with fever/possible infection
	Insufficient 25-hydroxyvitamin D
	Functional status: no changes from baseline
Discussion and summary	*z* scores were the best single data point for weight-for-length and indicate moderate malnutrition based on anthropometrics alone

CF, cystic fibrosis; FOC, frontal occipital circumference; IBW, ideal body weight; WHO, World Health Organization.

termed *malnourished* using the Ponderal Index. Korkmaz and colleagues[99] applied the CANSCORE to premature infants and looked at neonatal outcomes. They found an incidence of 54.8% of fetal malnutrition (100% in the SGA category and 44% in the AGA category). Furthermore, they found that the incidence of neonatal morbidities was significantly higher in premature infants with fetal malnutrition.

Overall, there is limited research available on the diagnoses of fetal malnutrition based on the CANSCORE and its comparison with long-term outcome data. In addition, it would also be important to ensure an experienced and qualified observer in the use of the CANSCORE since assessing neonates and especially premature infants could be more difficult due to thinner skin and less subcutaneous fat and muscle tissue in general. The CANSCORE is another example where a unique group of pediatric patients would possibly require adjustments in how to define malnutrition.

Case Studies

The following case study tables (Tables 3 and 4) are characteristic of the types of patient care cases routinely encountered at Texas Children's Hospital. They do not represent an actual patient.

Table 4. Case Study 2.

Assessment Criteria	Assessment Detail
Clinical presentation	Female (10 years, 3 months old) with recent worsening of ROD control
Diagnosis	ESRD with 3 times per week HD for 4 years
Anthropometrics	Weight/estimated dry weight: 23.3 kg (*z* score: −2.23 per CDC)
	Height: 130 cm (*z* score: −1.4)
	BMI: 13.8 (*z* score: −1.89)
	BMI *z* score adjusted for height/age: −1.46
	MUAC: 17.2 cm
	Per chronological age: 10th percentile, between −1 and −2 *z* score; moderate malnutrition (UNICEF)
	Per bone age: 15th–25th percentile, between 0 and −1 *z* score; no risk (UNICEF)
	Growth velocity
	Weight: = 700 g/1 year (5th–10th percentile, −0.52 *z* score over time)
	Height: +2.7 cm/1 year (3rd–5th percentile, ~ −2 *z* score)
	BMI *z* score change: −0.33
Food and nutrition-related history	750 mg sodium/potassium, low phosphorus, 500 mL fluid restriction. IDPN/IL 3 times/week during HD
	Picky eater, early satiety
	No food record obtainable due to limited social support; likely inadequate
	Fluid gains between treatments <5%
	Medication: ROD medications, appetite stimulant, 25-hydroxyvitamin D, no antihypertensives
	Unsure of medication compliance, refusal of GT placement. Growth hormone on hold.
Physical assessment	Overall appearance: Tanner stage 2, thin, short stature
	Head/face: flat, with some periorbital swelling noted possibly indicative of excess fluid
	Shoulders/torso: prominent scapula and protrusion of clavicle
	Upper extremities: little space between fingers at bicep/triceps; reduced fat mass
	Lower extremities: slight depression on inner thigh, little to no muscle definition in calf; reduced muscle mass. Knees recently started to touch. Moderate to severe muscle and fat losses noted
Clinical data	Serum albumin: low
	Normalized protein nitrogen appearance: normal
	Parathyroid hormone: high (trending down)
	Phosphorus: normal
	25-Hydroxyvitamin D: low (trending down)
	Iron: normal
	Transferrin saturation: normal
	Total iron binding capacity: normal
	Ferritin: normal
	Blood pressure under acceptable control
Functional status	Walking with limp. Occasionally transported via stroller. Significant decrease in physical function. No recent PedsQL scores available; previous study × 6 months ago showed no significant changes.
Overall nutrition status	**Illness-related chronic moderate malnutrition**
	Anthropometrics
	Weight velocity *z* score: decrease by 0.52
	BMI adjusted height/age *z* score: −1.46
	BMI *z* score change: decrease by 0.33
	MUAC at chronological age: moderate malnutrition per UNICEF
	Physical assessment
	Moderate to severe fat and muscle losses, possibly more significant if patient is hiding fluid given notable facial edema
	Etiology
	+ catabolic state given deterioration in chronic disease and catabolic nature of HD
	+ inflammation likely given deterioration in chronic disease
	Functional status
	Decline in physical function and capacity. 25-Hydroxyvitamin D insufficiency.
Discussion and summary	*z* scores initially indicate mild malnutrition. Patient's poor growth and declining functional status indicate a higher level of malnutrition. Decision to use UNICEF MUAC as primary indicator given possibility of positive fluid status. Ultimately, patient received transplantation shortly from these readings where fluid shifts in weights indicated patient's true dry weight and BMI *z* score of −2.93 with no notable changes in MUAC measures.

BMI, body mass index; CDC, Centers for Disease Control and Prevention; ESRD, end-stage renal disease; GT, gastrostomy tube; HD, hemodialysis; IDPN/IL, intradialytic parenteral nutrition/intralipids; MUAC, mid-upper-arm circumference; PedsQL, Pediatric Quality of Life Inventory; ROD, renal osteodystrophy; UNICEF, United Nations International Children's Emergency Fund.

Table 5. Malnutrition Codes/Descriptions Used for Baseline Data Collection.

ICD-9 Code	Description
260	Kwashiorkor
261	Nutritional marasmus
262	Other severe protein calorie malnutrition
263.0	Malnutrition of moderate degree
263.1	Malnutrition of mild degree
263.2	Arrested development following protein-calorie malnutrition
263.8	Other protein-calorie malnutrition
263.9	Unspecified protein-calorie malnutrition

ICD-9, International Classification of Disease, Ninth Revision.

Incorporating a New Approach to Malnutrition Into Existing Practice

An old African proverb states, "It takes a village to raise a child." Texas Children's Hospital is a 650-bed tertiary care hospital system. A hospital-wide readiness plan for the implementation of pediatric diagnosis-related groups (DRGs) evaluated severity of illness scores and found opportunity to improve diagnosis of comorbidities to more accurately reflect the acuity of the population served. Identification and stratification of malnutrition as a comorbidity was felt to be underidentified. Therefore, a group of stakeholders came together to evaluate the best way to approach this issue. We were fortunate that at the time the project started, the new definition and guidelines for malnutrition identification were "hot off the press," and we were eager to implement them into practice. When undertaking a paradigm changing approach to the identification and documentation of pediatric malnutrition, it helps to have the stakeholders at the table. Medical staff, administrators, clinical coding specialists, and finance and information services professionals in addition to clinical nutrition staff worked together to establish both the need and the process. The first step of this process was to identify and describe baseline population characteristics. We wanted to determine whether our population mimicked the literature in that a gap existed between prevalence and diagnosis of malnutrition as a comorbidity or major complication. Data were obtained for current rates of diagnosis of malnutrition as either primary or secondary discharge diagnosis for the prior fiscal year. *International Classification of Diseases* (ICD) codes (version 9) for malnutrition were used to search for these data (Table 5). Discharges from the neonatal ICUs (NICUs) were excluded due to limited applicability of the new definition to this population. Baseline diagnosis rates were estimated at approximately 2% of all discharges. To determine the prevalence, a total of 522 consecutive admittances were evaluated using percent ideal body weight based on Waterlow criteria (exclusive of patients who were less than 45 cm and 44 weeks postmenstrual age) as well as the criteria using *z* scores. Overall prevalence of malnutrition (mild to severe) was 19.7% by *z* score and 17.6% by Waterlow criteria (Table 6).[14]

Malnutrition is well established as an important comorbidity in children that affects both clinical outcomes and length of stay (LOS). Malnutrition has been shown to be significantly associated with a greater hospital LOS. In the STRONGkids study, there was an odds ratio of 1.96 for a LOS >4 days for those at nutrition risk vs those not at risk.[100] In a multicenter cohort study in Europe, the primary outcome was LOS in a general pediatric or surgery ward in malnourished vs well-nourished patients. Malnourished children had a significantly longer LOS compared with well-nourished children. Moderately and severely malnourished children stayed 1.3 and 1.6 days longer, respectively, than did well-nourished children. Not only does malnutrition upon admission increase LOS, but an increased LOS is associated with an increase in weight loss incidence (35% vs 23%).[27] Pacheco-Acosta et al[101] found their population consisted of well-nourished to mildly malnourished children admitted for noncritical illnesses and did not have a chronic disease. They found that an increased LOS (>5 days), having 5 or more stools daily, and lower respiratory tract disease were significant for having nutrition deterioration, defined as a >2% loss or >0.25 SD decrease in BMI from admission to discharge.

Identification, classification, and coding for the presence of malnutrition improve the ability to implement interventions to reverse or reduce its impact on both outcomes and LOS as well as affect the Severity of Illness (SOI) Index, which potentially influences care cost recovery.

Program Design, Planning, and Implementation

To facilitate a standardized approach to the identification and documentation of malnutrition among >50 pediatric clinical dietitians, a tool was created to simplify and standardize the process, and training began in earnest. A subcommittee of our Nutrition Coordinating Council took the lead in the project, spending countless hours reviewing literature, meeting with medical staff as well as coding specialists, and crafting the tool that would be used to implement the project. To ensure full participation in both training and execution of the plan, accountability for the malnutrition initiative was built into the performance management objectives for every pediatric clinical dietitian as well as clinical nutrition leadership. Compliance was monitored by chart audit as a component of departmental quality assurance monitors existing currently within a peer review process (Figure 2).

Training included Journal Club podium presentations (required and available to all campus sites via telehealth), small group trainings, case studies, and posttraining examinations. One-on-one trainings were also made available as the project neared pilot stages. References and materials were centrally housed on a shared drive for ease of access to all staff. Documentation standardization was achieved through the addition of domain-related sections added to an already existing nutrition assessment flow sheet in the electronic medical record (Figure 3). This facilitated ease of documentation, as well as created discrete data fields to be

Table 6. Difference in Malnutrition Identification and Prevalence of Malnutrition at Texas Children's Hospital.[a]

	Malnutrition Risk Identification *z* Score (ZS) vs Waterlow Criteria (WC)				
Malnutrition Level	WC No Risk	WC Mild	WC Moderate	WC Severe	WC Total
ZS no risk	**413**	6	0	0	419
ZS mild	17[b]	**45**	0	0	62 (11.9)
ZS moderate	0	11	**15**	0	26 (5.0)
ZS severe	0	1	7[c]	**7**	15 (2.9)
ZS total	430	63 (12.1)	22 (4.2)	7 (1.3)	**522**

Bolded items represent where comparable malnutrition levels were captured by both ZS and WC.
[a]Values are presented as number or number (%).
[b]Fisher exact test significant between no risk and mild malnutrition.
[c]Fisher exact test significant between moderate and severe malnutrition.

RD CHART AUDITS for _____ Auditor_____

Medical Record Number

Criteria				
1. Assessment and f/u completed within appropriate time frame.				
2. Approved Abbreviations				
3. Drug nutrient interaction / education provided when applicable				
4. Education: diet, formula mixing, food safety, etc. documented per standards				
5. Plan of Care completed/updated to reflect current needs (when applicable)				
6. Malnutrition criteria documented in POC when appropriate				
7. No obvious copy forward of note.				
Comments				
Nutrition Assessment				
1. Does assessment follow IDNT guidelines				
2. Assessment is succinct, relevant and appropriate to support nutrition diagnosis (PES)				
3. Appropriate comparative standards are used				
4. If "no nutrition diagnosis" is present/assigned; does assessment data support this conclusion				
Comments				
Nutrition Diagnosis				
5. Appropriate nutrition diagnosis (PES) statement is assigned based on data available				
6. PES statement is complete				
7. Diagnosis uses exact NCP terminology				
8. Etiology is root cause that RD can resolve or reduce signs/symptoms				
9. Signs/symptoms are specific, measurable and conducive to monitoring/evaluation				
10. Additional PES statements are noted when more than one problem is present/identified				
Comments				

PES= Problem, Etiology, Signs and Symptoms POC= Plan of Care IDNT=International Dietetics and Nutrition Terminology NCP= Nutrition Care Process

Figure 2. Sample quality assurance/peer review form. RD, registered dietitian. © 2013 Texas Children's Hospital. Used with permission.

enable data mining of malnutrition-related characteristics and outcomes of interventions for further studies. Documentation templates were created for ease of identification within the medical record for both providers and coders. Finally, data were collected for >500 patients by each of 2 randomly assigned registered dietitians for the purpose of establishing interrater reliability and reproducibility of the process as well as to establish validity of the tool. This provided staff with valuable practice in identification and stratification of malnutrition across all areas of the institution and facilitated a smooth transition when it came to applying the tools and techniques to familiar populations.

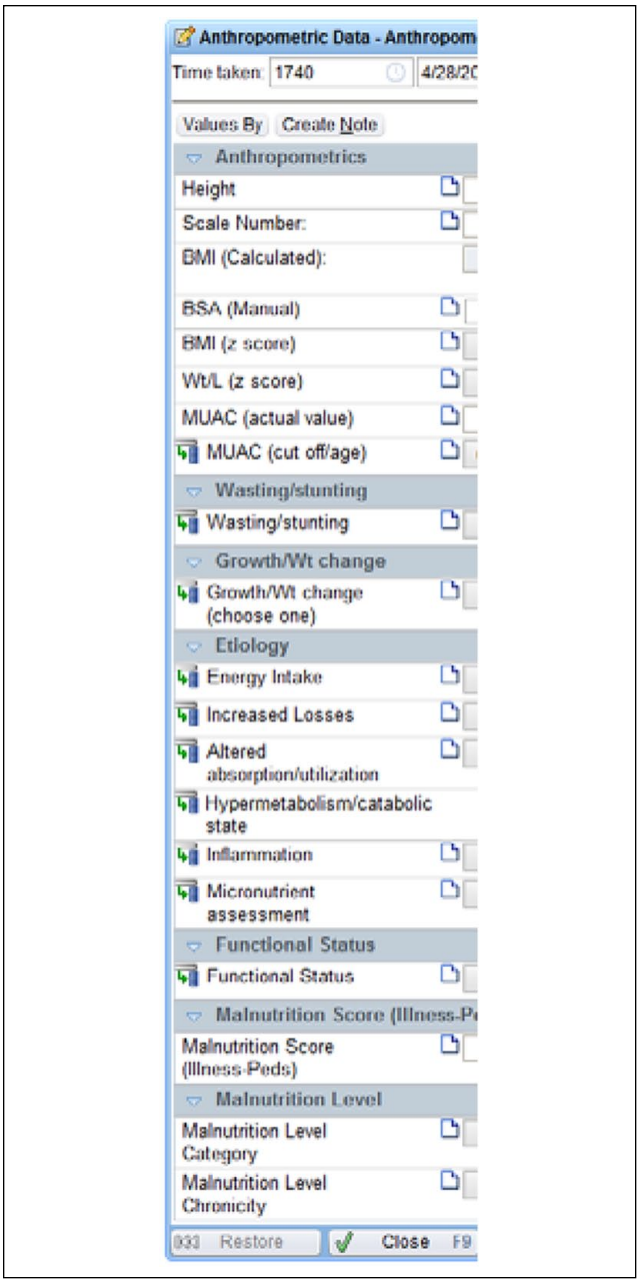

Figure 3. Screenshot of documentation flowsheet. © 2015 Epic Systems Corporation. Used with permission.

Results and Next Steps

Results from quality monitors indicate year to date compliance for dietitian documentation of malnutrition status at 95.8%. When malnutrition is identified by the dietitian as moderate or severe, and there is an active treatment plan in place, physicians are contacted by either the dietitian or the clinical coding specialist and asked to add the specific diagnosis to the problem and diagnosis list. At less than 1 full year postimplementation, this is felt to be a tremendous success. Malnutrition diagnosis rate by physician year to date based on all (non-NICU) discharges is 4.8%; this is increased from a baseline rate of 2%. Impact to the SOI Index and cost recovery evaluation are currently being evaluated. Moreover, the project has prompted staff to embark on creative research projects in pediatric malnutrition within specific populations.

Summary

Becker et al[5] and Mehta et al[4] present guidelines for assessing malnutrition in terms of anthropometric changes. New guidelines recommend the use of *z* scores in lieu of percentiles for anthropometric measurements. Establishing guidelines that include all domains of the new definition for pediatric malnutrition assessment is challenging. Further efforts should be made to include the etiologies of malnutrition, physical assessment, and functional status in a comprehensive assessment of pediatric malnutrition.

Further areas of research include use of MUAC in larger patient populations and special populations, growth velocity across all age groups, appropriate dietary intake for standard periods of time, how to interpret fat and muscle stores in terms of delayed/advanced Tanner stage, and bone age.

Statement of Authorship

S. S. Beer, M. D. Juarez, M. W. Vega, and N. L. Canada equally contributed to the concepts and content presented in the manuscript; critically revised the manuscript; and agree to be fully accountable for ensuring the integrity and accuracy of the work. All authors read and approved the final manuscript.

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