Prevalence of malnutrition in pediatric hospital patients

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Current Opinion in Pediatrics 2008, 20:590–596

Purpose of review
Hospital protein-energy malnutrition and its adverse consequences were already described back in 1980. The purpose of this review is to describe the current prevalence of malnutrition in hospitalized children and to describe current risk groups.
Recent findings
Different definitions have been used to describe malnutrition. According to WHO criteria, the SD score with a cutoff of less than −2 should be used to define malnutrition and to compare prevalence data. Using the SD score for weight for height or equivalent criteria, the prevalence of acute malnutrition over the last 10 years in hospitalized children in Germany, France, the UK and the USA varied between 6.1 and 14%, whereas in Turkey up to 32% of patients with malnutrition were reported. Acute malnutrition is still highly prevalent in children with an underlying disease; however, the prevalence rate seems lower in children with cystic fibrosis and malignancies.
Summary
The prevalence of acute malnutrition of children admitted to hospital is still considerably high, but there is a scarcity of data concerning the nutritional status during hospital admission. Screening tools to identify children at risk of developing malnutrition might be helpful.

Keywords
criteria, hospitalized children, malnutrition, prevalence

Curr Opin Pediatr 20:590–596

1040-8703

Introduction

Nutritional support is an essential aspect of the clinical management of children admitted to hospital [1]. The mean length of hospital stay of most children is only a few days, but can be considerably longer in some children with chronic diseases or underlying problems. During their brief stay, attention is mostly focused on the primary medical problem. There is still little attention given to the child's nutritional status, whereas it has been known since the early 1980s that the prevalence of acute and chronic malnutrition of children admitted to the hospital is highly dependent on the criteria used [2–4]. The purpose of this review is to describe the current prevalence of malnutrition in pediatric hospital patients, to describe risk groups and to describe those children who are at risk of becoming malnourished.

Definition of malnutrition

Malnutrition can be defined as a state of nutrition in which deficiency or excess of energy, protein, and other nutrients causes measurable adverse effects on tissue and body form and function, and clinical outcome.

Malnutrition can be of the acute, chronic or mixed type. Acute malnutrition is the type that usually occurs in illness, but children with underlying chronic diseases who are admitted to the hospital because of an acute illness can also present with chronic malnutrition.

Anthropometric variables are used to define nutritional status worldwide but various classification systems and cutoff points are used to define malnutrition. One such classification method includes kwashiorkor and marasmus. These terms were originally established to describe syndromes of protein-energy malnutrition in children in developing countries.

The most used classification system was that described by Waterlow [5], in which acute and chronic malnutrition were divided into four stages, on the basis of the actual weight to the 50th percentile of WFH for acute malnutrition and the actual height to the 50th percentile for height for chronic malnutrition.

In 1992, the international statistical classification of disease and related health problems used weight, expressed as SD scores, to define the probability of malnutrition. For example, an SD score between −1 and −2 (representing 13.5% of the reference population) indicates a probability of mild malnutrition and an SD score of less than −2 indicates a probability of severe

malnutrition (2.3%). This statistical approach does not use weight-for-height index and does not define the reference population. In 1999, the World Health Organization [6] recommended an additional classification for malnutrition in children, which became widely used. The likelihood of malnutrition is defined using a cutoff point of −2 SD. A child with a SD score between −1 and −2 is no longer defined as malnourished. According to these WHO criteria, a SD score for WFH between −3 and −2 can be considered as moderate malnutrition and a SD score below −3 as severe malnutrition.

Recently, Cole *et al.* [7••] determined cutoff points for BMI to define thinness. A thinness cutoff linked to 17 kg/m^2 was close to the wasting cutoff based on −2 SD scores.

Table 1 ([5,6,8,9]) shows the most frequently used anthropometric criteria for malnutrition.

Worldwide, with regard to classification systems, 63% of the countries use charts percentiles, 18% SD scores, and 6% percentage-of-median [10]. Currently, the most established way to describe malnutrition is the use of SD scores with the reference population defined as the reference charts from a specific country or from the standard international reference chart of the National Centre for Health and WHO.

For the purpose of this review, acute malnutrition (severe and moderate) is defined as one of the following:

(1) WFH SD score less than −2,
(2) WFH less than 80% of the median,
(3) % ideal body WFH less than 80,
(4) WFH less than 5th percentile,
(5) BMI SD score less than −2.

Chronic malnutrition is defined as:

(1) height for age (HFA) SD score less than −2,
(2) HFA less than 90% of the median,
(3) HFA less than 5th percentile.

Only studies regarding patients in Europe, North and South America were included.

For some congenital syndromes (e.g. Down's syndrome) and other health conditions associated with growth abnormalities (such as the low-birth-weight infant), disease-specific growth references would be more appropriate for more accurately assessing nutritional status [11]. These specific growth references are beyond the scope of this review.

Consequences of malnutrition

Children have a high energy need per unit of body mass compared with adults and have limited energy reserves. Furthermore, children, unlike adults, have a need for growth, which puts them at a particularly high risk of malnutrition because of these higher demands. For this reason, the likelihood of developing serious nutritional deficiencies is high and increases when the child is admitted to the hospital for longer periods of time.

Malnutrition was shown to be associated with increased morbidity and mortality in both children and adults [12,13], including a higher risk of infections due to poor immune defense, wound healing problems, reduced gut function, longer dependency on mechanical ventilation and longer hospital stay [14]. Other studies [15,16] revealed that severe trauma, such as burns, affects children's nutritional status and growth for up to 2 years.

Furthermore, malnutrition in infancy is associated with poor growth and reduced or delayed mental and psychomotor development [17,18]. Longitudinal studies have revealed that malnutrition during infancy is associated with increased behavior problems during childhood, including attention deficit and aggressive behavior [19–21]. Early childhood malnutrition has also been related to externalizing behavior in both childhood and adolescence [22,23].

Increasing evidence suggests that many common adult diseases have their origins in fetal and early life. It is suggested that poor nutrition during fetal life and early infancy can increase the risk of developing type II diabetes, hypertension and cardiovascular disease in adult life [24].

Prevalence of acute malnutrition in hospitalized children with mixed diagnoses

The reported prevalence of acute malnutrition in infants and children with mixed diagnoses admitted to hospital ranges from 6.1 to 40.9% (Table 2 [25•,26–33]).

Table 1 Criteria for defining acute malnutrition

Reference	'Mild'	'Moderate'	'Severe'
Gomez *et al.* [8]	75–90% standard weight	60–74% standard weight	<60% standard weight
Tanner *et al.* [9]		<5th percentile WFH	
Waterlow [5]	80–90% WFH	70–80% WFH	<70% WFH
WHO [6]		−3 < WFH SD score < −2	WFH SD score < −3

WFH, weight for height.

Table 2 Prevalence of acute malnutrition in hospitalized children with mixed diagnoses

Reference	Country	Age	*n*	Prevalence (%)*	Definition
Pawellek *et al.* [25•]	Germany	All ages	475	6.1	WFH < 80%
Rocha *et al.* [26]	Brazil	<5 years	186	6.9	WFH < −2 SD
Marteletti *et al.* [27]	France	2 months–16 years	280	11	WFH < −2 SD
Dogan *et al.* [28]	Turkey	1 month–23 years	528	27.7	WFH < −2 SD
Ozturk *et al.* [29]	Turkey	2–6 years	170	31.8	% ideal BW/H <80%
Hankard *et al.* [30]	France	>6 months	58	21	BMI < −2 SD
Hendricks *et al.* [31]	USA	0–18 years	268	7.1	WFH < 80%
Hendrikse *et al.* [32]	UK	7 months–16 years	226	8.0	WFH < 80%
Moy *et al.* [33]	UK	3 months–18 years	255	14	WFH < −2 SD

BW/H, bodyweight for height; WFH, weight for height.
* Prevalence (%) derived from original studies using equivalent criteria.

Most recently, Pawellek *et al.* [25•] reported about the prevalence of malnutrition in a group of 475 unselected children admitted to a hospital in Munich, Germany. Using cutoff points defined by Waterlow (WFH < 80th percentile), they found 6.1% of the patients malnourished. With respect to age, the highest risk for malnutrition was found in infants (7.1%) and young children aged 2–5 years (4.3%).

A similar prevalence rate of 7.1 and 8%, respectively, using the same criterion was reported more than 10 years ago by Hendricks *et al.* [31] in a group of 268 children admitted in Boston, USA and by Hendrikse *et al.* [32] in a group of 226 children admitted in Glasgow, UK.

Using the SD criteria −2 for WFH, Moy *et al.* [33] in the UK and Dogan *et al.* [28] in Turkey found, respectively, 14 and 27.7% malnourishment. Moy *et al.* [33] studied a group of 255 patients aged 3 months to 18 years and Dogan *et al.* [28] studied a group of 528 patients aged 1–17 years. Of these 528 children (31.6%) were admitted with an acute disease and 68.4% with a chronic disease. The remarkably high percentage of malnourishment found by Dogan *et al.* [28] was also reported by Ozturk *et al.* [29]. In this study, a prevalence of 31.8% for malnutrition was found in a group of 170 children admitted to a tertiary center using percentage of ideal body weight less than 80%.

Hankard *et al.* [30] and Marteletti *et al.* [27] both performed a 1-day cross-sectional survey in a pediatric population admitted to medical or surgical units in France. Hankard *et al.* [30] studied a group of 58 children older than 6 months and hospitalized for more than 48 h and found 12% of the children to be malnourished, using the BMI criteria below −2 SD. Marteletti *et al.* [27] found a prevalence of 11% in a group of 280 children.

In conclusion, using equivalent criteria, the prevalence of malnutrition in patients admitted to hospitals in Germany, France, the UK and the USA varied between 6.1 and 14%, whereas in two hospitals in Turkey up to 32% of patients with malnutrition were reported. Over the last 10 years, a decrease in the prevalence of malnutrition cannot be noticed.

Prevalence of acute malnutrition in hospitalized children with an underlying disease

In this section, we will discuss studies concerning prevalence rates of malnutrition among children admitted to the hospital with an underlying disease.

Cardiac disease

Cardiac cachexia refers to a syndrome of protein-energy malnutrition seen in patients with chronic cardiac disease. A high prevalence percentage of low WFH is reported most commonly in patients with chronic congestive failure, chronic shunt hypoxemia and nosocomial postoperative acute and chronic states. Various studies [31,33–38] among children with various cardiac diseases (e.g. congenital heart disease, idiopathic dilated cardiomyopathy) showed prevalence rates between 18 and 64% on admission. The highest rates were found in cardiac surgical patients and in children with congenital heart diseases and left-to-right shunt.

The actual prevalence might be even higher because many patients have fluid retention at the time of admission.

Cystic fibrosis

Malnutrition is an extremely substantial complicating factor in patients with cystic fibrosis. A poor nutritional status is a negative prognostic factor and malnutrition and deterioration of lung function are interrelated and interdependent. Substantial improvements in medical management including nutritional therapy have been made. Prevalence rates of malnutrition among cystic fibrosis patients have changed in the last decade. Pawellek *et al.* [25•] reported a rate of 8.3% in 2008, using the criterion less than 80% WFH, whereas Hendricks *et al.* [31] reported a rate of 42% severe malnutrition (WFH < 70%) in hospitalized children with cystic fibrosis.

In the USA, in 1999, it was reported that 24% of the cystic fibrosis patients had a weight less than the 5th percentile [39]. In a very large study in the USA ($n = 13\,116$), children below 1 year and above 10 years appeared to be at more risk of acute malnutrition than children aged 1–10 years [40]. These age-related findings were less obvious in a large German study [41].

Malignancy

Malnutrition in childhood cancer is a common and serious problem. Besides the previously mentioned consequences of malnutrition, it is associated with a decreased tolerance to chemotherapy. Although malnutrition is not uniformly found in all pediatric malignancies, certain types of malignancies are at high nutritional risk (solid tumors, medulloblastoma, acute nonlymphocytic leukemia, and multiple relapse leukemia). Furthermore, marked differences in the prevalence of malnutrition will be found between children on therapy and those off therapy [42]. The use of body weight to assess nutritional status in pediatric cancer patients has been misleading because of the confounding effects of tumor mass [43]. This may explain why other authors have suggested that children with cancer and those undergoing chemotherapy or a bone marrow transplantation are at a lower risk of malnutrition than children with other conditions [31,33].

Previously, up to 50% of pediatric patients with malignancies were reported to be undernourished [44]. Recently, Pawellek *et al.* [25•] reported a prevalence rate of 9.1% acute malnutrition (<80% WFH) in patients with pediatric malignancies on admission. In a study among 1033 patients with acute lymphoblastic leukemia, Reilly *et al.* [45] found a rate of about 7% malnutrition (BMI < -2 SD). den Broeder *et al.* [46] observed malnutrition (WFH < -2 SD) in 28% of the patients with a solid tumor.

Renal disease

In children with chronic kidney disease, both acute and chronic malnutrition are highly prevalent, and become more pronounced when dialysis treatment is initiated. In a mixed population study [28], malnutrition was observed in 64% of the children with kidney insufficiency using WFA SDS score less than -2.

Sylvestre *et al.* [47•] found a great variation in the prevalence of malnutrition depending on the criteria used in 64 patients with chronic kidney disease (53% WFA < -2 SD, 64% HFA < -2 SD, 6% WFH < -2 SD). With SD scores adjusted for age, 5% of the patients had a weight for age of less than -2 SD. Accordingly, Pereira *et al.* [48] reported in 30 patients with end-stage renal disease a prevalence of 53% using less than -2 SD for WFA and 63% using less than -2 SD for HFA.

Pediatric intensive care

Despite improvements in intensive care technology, feeding possibilities and increased awareness of the significance of adequate nutritional support, Hulst *et al.* [49] still found 24% of the children to be acutely and chronically malnourished on admission to the pediatric intensive care unit (PICU) (WFH < -2 SD or HFA < -2 SD). There was a high prevalence (84%) of underlying growth-affecting disease in those with acute malnutrition. On discharge, on average for the preterm and term neonates together, acute and chronic malnutrition rates had increased to 26 and 48%, respectively, whereas the prevalence of malnutrition in the older children was found not to have changed during the ICU stay.

This study is the only study in which the nutritional status of pediatric intensive care patients was followed during admission and 6 weeks and 6 months after discharge. Most children had good long-term outcome in terms of nutritional status after discharge.

Neurological disorders

In general, poor nutritional status and growth is often seen in children with neurological disorders. It is advocated to use specific weight charts for specific diseases such as Duchenne's muscular dystrophy. The precise prevalence varies depending on the criterion by which malnutrition is defined, the degree of mental retardation, the presence of associated problems, treatment administered, and socioeconomic and family environment [50]. In the study of Sanchez-Lastres *et al.* [50] eight different criteria were used to define the nutritional status of mentally retarded children on the basis of anthropometric variables. The prevalence of malnutrition increased with age, increasing intelligence quotient deficit and cerebral palsy.

In children with Duchenne muscular dystrophy, malnutrition occurs after the age of 14 years, involving 54% of boys at about 18 years of age [51]. Evaluating developmentally disabled children is often difficult because they do not fit into normal standards for assessment. In children with cerebral palsy, malnutrition is associated with the degree of feeding dysfunction [52–56]. Recently, Pawellek *et al.* [25•] found in a mixed population, using the criterion less than 80% WFH, malnutrition in 24% of the children with mental retardation.

In conclusion, a summary was given of the prevalence of malnutrition in a selection of children with an underlying disease. The main finding is that malnutrition is still highly prevalent in children with an underlying disease. However, compared with data from 20 to 30 years ago, the prevalence rate of malnutrition seems to be diminished especially in children with cystic fibrosis and malignancies. In children with chronic inflammatory diseases such

as chronic kidney disease, both acute and chronic malnutrition remain highly prevalent, probably due to the ongoing inflammatory state. For diseases such as inflammatory bowel disease and AIDS (not reported in this manuscript), the nutritional status is also dependent on the degree of inflammation.

In children with neurological disorders, attention should be focused on appropriate methods of nutritional assessment to get a reliable picture of the nutritional status.

Prevalence of chronic malnutrition in hospitalized children

Only a few studies reported the prevalence of chronic malnutrition in hospitalized children. Hendricks *et al.* [31] used the Waterlow criteria (<90% HFA) and reported 12.8% chronic malnutrition, whereas Hendrikse *et al.* [32] and Rocha *et al.* [26] using HFA less than −2 SD reported 8 and 18.2% chronic malnutrition, respectively.

In several studies in children with an underlying disease, a high prevalence of chronic malnutrition is found. For children with various cardiac diseases, prevalence rates of between 24 and 44% were reported [34–37]. In pediatric malignancies, chronic malnutrition has hardly been reported. Yaris *et al.* [57] reported a prevalence rate of 2.1%. In patients with chronic kidney disease, Sylvestre *et al.* [47•] and Perreira *et al.* [48] found a HFA less than −2 SD in, respectively, 64 and 63% of the patients.

In conclusion, the highest prevalence of chronic malnutrition is found in children with a chronic underlying disease, especially in children with a chronic cardiac or renal disease.

Prevalence of malnutrition during hospitalization in children with mixed diagnoses

Studies on the prevalence of developing malnutrition or deterioration of nutritional status during hospitalization are scarce. Sermet-Gaudelus *et al.* [58] reported that 191 out of the 296 studied children lost weight during admission, 25.6% lost more than 5% weight, 44.5% lost 2–5% weight and 29.9% lost less than 2% weight. In this study, poor nutritional status at admission did not increase the risk of nutritional depletion during the hospital stay.

Rocha *et al.* [26] found that 96 (51.6%) of the 186 children who completed the study exhibited weight loss (mean loss of 0.41 ± 0.26 kg) and 84 (45.2%) of them gained weight (mean gain of 0.43 ± 0.16 kg), whereas the weights of the remaining six children remained unaltered. The disease most frequently responsible for weight loss was pneumonia (in 76% of the children). Children who had malnutrition on admission were still malnourished at hospital discharge and 9% of well nourished children developed mild malnutrition while hospitalized. Prolonged hospitalization was linked with weight loss in hospital.

Ozturk *et al.* [29] described that the children with undernutrition on admission showed a significant decrease in percentage of BMI on discharge, whereas well nourished children did not deteriorate during hospitalization.

Screening tools to identify children at risk of malnutrition

To prevent malnutrition and especially hospital-acquired malnutrition, the risk of nutritional depletion needs to be identified at the time of admission so that appropriate nutritional intervention can be initiated at an early stage. Routine nutritional screening is rarely carried out in pediatric patients due to the lack of a simple and valid nutritional screening tool. Only two screening tools have been published since 2000 to identify children at risk of malnutrition. Sermet-Gaudelus *et al.* [58] described a simple pediatric nutritional risk score, which is suitable for routine use to identify patients at risk of malnutrition during hospitalization. Nutritional risk was assessed prospectively in 296 children by evaluating various factors within 48 h of admission. Multivariate analysis indicated that food intake less than 50%, pain, and grades 2 and 3 pathologic conditions were associated with weight loss of more than 2%. These significant risk factors were scored (one point for food intake <50%, one for pain, one for grade 2 pathologic condition, and three for grade 3 pathologic condition) and add up to a nutritional risk score ranging from 0 to 5. A score of 1 or 2 indicated moderate risk and a score of more than 2 indicated high risk of malnutrition. Of the patients who lost less than 2% of their reference weights, 25% were in the moderate class, and 78% were in the high-risk class.

Secker and Jeejeebhoy [59••] recently reported the use of the subjective global nutritional assessment (SGNA) screening tool. Prospectively, the preoperative nutritional status of 175 children having major thoracic or abdominal surgery was evaluated with the use of SGNA and objective measurements. The SGNA consisted of a nutrition-related physical examination and gathered information on the child's recent and current height and weight history, parental heights, dietary intake, frequency and duration of gastrointestinal symptoms, current functional capacity and recent changes. These items together led to a global assessment of the patient's nutritional status, assigning a global rating of well nourished, moderately malnourished, or severely

malnourished. A rigid scoring system based on specific criteria was not used. SGNA successfully divided children into the three groups with significantly different mean values for various anthropometric measures. SGNA was considered a valid tool for assessing nutritional status in children and identifying those at higher risk of nutrition-associated complications and prolonged hospitalizations.

Both methods described by Sermet-Gaudelus *et al.* [58] and Secker and Jeejeebhoy [59••] link nutritional status to outcome. Both methods have their limitations in use. The tool of Sermet-Gaudelus *et al.* [58] needs a period of 48 h after admission to complete and the study results of Secker and Jeejeebhoy [59••] were not based on a single assessor but were a composite of the data of five assessors. For both methods, skilled staff are necessary and the procedures seem to be time-consuming.

Conclusion

Various definitions are used to describe the prevalence of malnutrition, but in order to compare prevalence data appropriately uniform definitions (WHO definition with SD scores) should be used.

The prevalence of acute and chronic malnutrition of hospitalized children is still substantial, especially in children with an underlying disease. There is a scarcity of data about the nutritional status of children during admission and children who are at risk of developing malnutrition. In order to decrease the prevalence of malnutrition among children who are admitted to hospital, it is important to identify the children at risk at an early stage so that appropriate nutritional intervention can be initiated. Future studies should focus on follow-up studies of those children who are at risk and the effect of early nutritional intervention. Therefore, a simple nutritional screening tool should be implemented and used for all children admitted to hospital.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

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Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 623).

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In this study, the preoperative nutritional status of 175 children was determined with the use of SGNA. With this assessment, children could be divided into three groups (well, moderately and severely malnourished). Furthermore, this is one of the few studies that have showed a relation between nutritional status and postoperative length of stay and infectious complications.