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Article *in* Archives of Disease in Childhood · May 2009

DOI: 10.1136/adc.2008.157255 · Source: PubMed

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Accepted 19 April 2009
Published Online First 3 May 2009

ABSTRACT

Objective: Nationwide prevalence studies on malnutrition in hospitalised children have not been done. This study aimed to investigate the prevalence of malnutrition of all newly admitted children in The Netherlands during 3 consecutive days.

Design: Prospective observational study.

Setting: Paediatric wards of 44 hospitals (7 academic and 37 general).

Participants: A total of 424 children aged ⩾30 days and hospitalised for ⩾ 1 day were included, 63% male, 86% non-white. Median age was 3.5 years and median hospital stay was 2 days.

Main outcome measures: SD scores <−2 for weight for height and height for age were considered to indicate acute and chronic malnutrition, respectively.

Results: Overall 19% of the children had acute and/or chronic malnutrition at admission (academic 22% and general 17%). The proportion of children with chronic malnutrition was significantly higher in academic hospitals (14% vs 6%). Logistic regression analysis allowing for age, underlying disease, ethnicity, surgery and type of centre showed a significant relation between the presence of malnutrition at admission and underlying disease (odds ratio (OR) 2.2). For chronic malnutrition both underlying disease and non-white ethnicity were significantly related to a higher prevalence (OR 3.7 and OR 2.8, respectively). Multiple regression analysis showed that children with acute malnutrition stayed on average 45% longer (95% CI 7% to 95%) in the hospital than children without such malnutrition.

Conclusions: This unique nationwide study shows that 19% of children admitted to Dutch hospitals are malnourished at admission. This high prevalence underlines the need for routine screening and treatment of malnutrition in hospitalised children.

What is already known on this topic

- The prevalence of acute malnutrition over the last 10 years in hospitalised children in Germany, France, UK and the US varied between 6% and 14%, whereas in Turkey a percentage up to 40% malnutrition was reported.
- Acute malnutrition is highly prevalent in children with an underlying disease.
- Prevalence studies on malnutrition in paediatric hospital patients were done in single, mainly tertiary, centres.

What this study adds

- Prevalence data of acute and chronic malnutrition obtained from a nationwide study.
- Multivariate analysis showing a significant relation between the presence of malnutrition and underlying disease, and an association between the presence of acute malnutrition and a longer hospital stay.

There are limited data available on the prevalence of malnutrition in children admitted to the hospital and data concerning the nutritional status during admission and at discharge are even scarcer.

Malnutrition is associated with increased morbidity and mortality in children including a higher risk of infections due to poor immune defence, wound healing problems, reduced gut function, longer dependency on mechanical ventilation and longer hospital stay. Furthermore, malnutrition in infancy is associated with poor growth and reduced or delayed mental and psychomotor development. In order to decrease the prevalence of malnutrition among children who are admitted in the hospital it is important to identify the children at risk at an early stage so that appropriate nutritional intervention can be initiated.

Hospital protein-energy malnutrition has already been described back in 1980[1] and current studies report variable percentages depending on the methods used and countries involved.[2–15] The largest proportion of malnourished children was found among children with multiple diagnoses, mental retardation, infectious diseases and cystic fibrosis.[15] In only two studies was the deterioration of nutritional status during hospital admission reported[2 14] with, respectively, 52% and 65% of children experiencing weight loss.

All these studies on the prevalence of malnutrition among hospitalised children and the deterioration of nutritional status during admission, however, were performed in single centres. The aim of our study was to screen the nutritional status of all children admitted to all paediatric wards in The Netherlands during three consecutive days.

METHODS

All 101 Dutch hospitals with a paediatric ward—that is, 93 general and eight academic hospitals were invited by letter to participate in this study on a voluntary basis. The three screening days took place on 26, 27 and 28 November 2007. The inclusion criteria were age >1 month, admission to a medium care unit and an expected stay of at least

1 day. The institutional review board of Erasmus Medical Centre approved the study protocol and waived the need to ask for informed consent of each parent because of the standard nature of the measurements in the protocol. Parents or caregivers were informed by a letter approved by the institutional review board and could refrain from participation without consequences.

For all children age, sex, diagnosis and length of hospital stay was recorded. Race was classified as white and non-white. Children were classified by the treating physician as surgical and non-surgical and with or without an underlying disease. Reasons for admission were classified as respiratory, trauma, infectious, surgical, oncological, gastro-intestinal, cardiac, neurological and others.

Measurements of weight were performed on admission and discharge. Supine length or standing height assessment was performed on admission. All measurements were done in a standardised way and using standard equipment (digital scales, stadiometer) as explained to participating hospitals beforehand.[16] The measurements were performed by the nursing staff or attending doctors. All anthropometric data were compared with published standards based on a Dutch reference population and translated into standard deviation (SD) scores.[17] This resulted in SD scores for weight for height (WFH), and height for age (HFA). An SD score <-2 for WFH was used to indicate acute malnutrition, and an SD score <-2 for HFA was used to indicate chronic malnutrition. Overall malnutrition was defined if acute malnutrition and/or chronic malnutrition were present.

Children younger than 2 years with a history of prematurity were analysed according to corrected age.

Discharge data were compared to the measurements at admission in children with a length of stay of at least 4 days.

Statistical analysis

Descriptive analyses were used to describe the study population and the feasibility of performing the measurements. Continuous outcomes are summarised using median and range. χ^2 Tests were used to compare percentages between groups. Comparison of continuous data between groups was done using the Mann-Whitney U test.

Simultaneous evaluation of various factors regarding the prevalence of malnutrition was done by logistic regression. Multiple regression analysis regarding the length of hospital stay (LOS) was used to evaluate relations with various clinical factors. Logarithmic transformation of the LOS was applied to minimise the influence of outliers. As considerable skewness remained after this transformation, standard errors were calculated using the bootstrap method (1000 replications) with Stata software. We considered A p value (two-sided) <0.05 to be significant.

RESULTS

General

The overall response rate was 52% (52 hospitals, seven academic and 45 general). Four of the 45 general hospitals did not include patients and four did not return the case record forms. Finally, 44 hospitals participated (seven academic and 37 general). A total of 424 children met the inclusion criteria (172 academic and 252 general). Baseline characteristics are shown in table 1. The median age was 3.5 years (31 days–17.7 years), 63% were male, 86% white. Median length of hospital stay was 2 days (range 1–44 days); 24% of the children were in hospital for more than 4 days. Twenty-three per cent of children were admitted because they needed surgery. Overall, 29% of the admitted children had an underlying disease with a significant difference between the academic and general hospital population (51% vs 15%, respectively, $p<0.001$).

Admission data

Weight and length measurements were available in 99% and 92% of children. The percentage of children with acute malnutrition was 11% (95% CI 8% to 15%) and with chronic malnutrition was 9% (95% CI 6% to 12%). Prevalence rates of malnutrition in the overall group and several subgroups are described in table 2. Overall, the prevalence of malnutrition was 19% (95% CI 15% to 23%). Within this group of malnourished children, 44% was known to have an underlying disease such as cerebral palsy or neurological disease (n = 7), congenital heart anomalies (n = 6) or metabolic disease (n = 2).

Univariate analysis

There was a significant difference between academic and general hospitals in the prevalence of chronic malnutrition, 14% vs 6%, respectively ($p = 0.013$), with no significant

Table 1 Patient characteristics and diagnoses

Patient characteristics	Total (n = 424)	Academic (n = 172)	General (n = 252)
Sex, M:F (%)	63:37	62:38	64:36
Median age (range)	3.5 (31 days –17.7 years)	5.7* (39 days –17.7 years)	2.2 (31 days –17.6 years)
Median length of hospital stay (days) (range)	2 (1–44)	2 (1–33)	2 (1–44)
Underlying disease (%)	29	51†	15
Diagnostic groups (%)			
Infectious	32	9	47
Surgical	23	37	13
Gastrointestinal	16	17	15
Respiratory	6	5	7
Cardiac	4	9	1
Trauma	4	1	6
Oncological	4	9	0
Neurological	3	5	2
Other	8	8	9

*Significant difference compared to general hospitals ($p = 0.001$).
†Significant difference compared to general hospitals ($p<0.001$).

Table 2 Prevalence rates of malnutrition at admission in the total group and various subgroups

Prevalence of malnutrition	Acute (%)	Chronic (%)	Overall (%)
Total group	11	9	19
Type of hospital			
Academic hospitals	11	14	22
General hospitals	12	6	17
Age categories			
<1 year	14	6	18
2–5 years	14	8	21
6–12 years	7	12	17
13–17 years	10	11	19
Ethnic background			
White	11	7	17
Non-white	15	19*	28
Underlying disease			
Yes	14	18†	28‡
No	10	5	15
Surgical			
Yes	8	10	14
No	13	9	20
Diagnostic groups			
Infectious	14	3	17
Surgical	8	10	14
Gastrointestinal	18	15	28
Respiratory	15	15	30
Cardiac	13	13	25
Trauma	8	0	8
Oncological	0	13	13
Neurological	0	31	31
Other	9	6	15

Acute malnutrition defined as weight for height SDS <-2; chronic malnutrition defined as height for age SDS <-2.
*Significantly higher prevalence than in white group ($p = 0.017$).
†Significantly higher prevalence than in group with no underlying disease ($p<0.001$).
‡Significantly higher prevalence than in group with no underlying disease ($p = 0.004$).

differences between centres within the academic and general hospital group. Comparing age groups no differences were found in the prevalence of malnutrition. The prevalence of chronic malnutrition was significantly higher in non-white children compared with white children, 19% vs 7% ($p = 0.017$). Children with an underlying disease had a significantly higher overall prevalence of malnutrition and prevalence of chronic malnutrition compared to those without an underlying disease, 28% vs 15% and 18% vs 5%, respectively ($p = 0.004$ and $p<0.001$). These associations did not significantly differ between the two types of hospital.

Comparing diagnostic groups showed the highest prevalence for acute malnutrition for gastrointestinal disorders (18%). For chronic malnutrition, the highest prevalence was found in children with neurological disorders (31%).

The median duration of hospital stay of children with acute malnutrition was significantly longer compared with those without such malnutrition, median 4 (range 1–44) days vs 2 (1–24) days, respectively ($p = 0.001$). This difference was similar in academic and general hospitals ($p = 0.055$ and 0.006, respectively).

Multivariate analysis

Multiple logistic regression analysis allowing for age, underlying disease, ethnicity and surgery showed a significant relation between the presence of malnutrition at admission and underlying disease (OR = 2.2, CI 1.3 to 3.9; $p = 0.005$). For acute malnutrition no significant factors were found, whereas for chronic malnutrition both underlying disease and non-white ethnicity were significantly related to a higher prevalence (OR 3.7, CI 1.7 to 7.8; $p = 0.001$ and OR 2.8, CI 1.2 to 6.6; $p = 0.016$, respectively).

Table 3 Results of multiple regression analysis regarding the relation between length of hospital stay and various clinical factors

Factor	Ratio of geometric means (95% CI)	p Value
Surgery, yes vs no	0.63 (0.5 to 0.8)	<0.001
Underlying disease, yes vs no	1.35 (1.1 to 1.7)	0.015
Age groups		
Age 2–5 years vs age <1 year	0.78 (0.6 to 0.9)	0.020
Age 6–12 years vs age <1 year	0.74 (0.9 to 0.9)	0.008
Age 13–17 years vs age <1 year	0.73 (0.5 to 0.9)	0.040
Hospital, general vs academic	0.86 (0.7 to 1.0)	0.157
Ethnicity, non-white vs white	1.40 (1.1 to 1.8)	0.007
Acute malnutrition, yes vs no	1.45 (1.1 to 2.0)	0.016

Multivariate regression analysis showed that the presence of acute malnutrition, non-white ethnicity and the presence of underlying disease were significantly related to a longer hospital stay (table 3). Children with acute malnutrition stayed on average 45% longer in the hospital than children in a normal nutritional status. Being admitted for surgery was significantly related to a shorter duration of stay. The type of hospital was not significantly related to length of stay. The presence of chronic malnutrition or overall malnutrition was not significantly related to a longer hospital stay when corrected for the other clinical factors ($p = 0.414$ and $p = 0.097$, respectively).

At discharge

Of the 103 children who were in hospital for more than 4 days the median length of stay was 8 days (range 5–44). For this group prevalence rates of acute and chronic malnutrition at admission were 21% and 8%, respectively. Data for both weight and height at discharge were available for 62 of the 103 children (60%). Within this group 65% of the children lost no weight or gained weight, and 3% had a weight loss more than 5% during admission. The percentage of children with acute malnutrition did not change between admission and discharge. Children with acute malnutrition and admitted for more than 4 days did not lose more weight during admission than children with a good nutritional status at admission.

DISCUSSION

This unique nationwide screening study performed in 46 hospitals in The Netherlands shows that 19% of admitted children have acute or chronic malnutrition at admission; 11% acute and 9% chronic. The overall prevalence of malnutrition was significantly higher in children with an underlying disease, 28% vs 15%. There was a markedly difference in chronic malnutrition between academic and general hospitals, 14% vs 6%. This difference could largely be explained by the higher proportion of children with underlying disease in academic centres (51% vs 15%).

The second main finding of this study is that children with acute malnutrition on admission had a significantly longer length of hospital stay than children with a normal nutritional status, also when corrected for other clinical factors.

The strength of this study is that to our knowledge, this is the first study looking into the prevalence of malnutrition among hospitalised children that is performed in a nationwide setting. Previous studies on this topic were only done in single centres,

Table 4 Prevalence of acute malnutrition in hospitalised children with mixed diagnoses

Author, year	Country	Age	No	Prevalence (%)	Definition
Pawellek, 2008	Germany	All ages	475	6.1	WFH <80%
Rocha, 2006	Brazil	<5 years	186	6.9	WFH <−2 SD
Marteletti, 2005	France	2 months–16 years	280	11	WFH <−2 SD
Hankard, 2001	France	>6 months	58	12	BMI <−2 SD
Sermet-Gaudulus, 2000	France	>1 months	296	19	% ideal BW/A <80%
Hendricks, 1995	USA	0–18 years	268	7.1	WFH <80%
Hendrikse, 1997	UK	7 months –16 years	226	8.0	WFH <80%
Moy, 1990	UK	3 months –18 years	255	14	WFH <−2 SD

Prevalence rates adapted from original studies.
BMI, body mass index; BW/A, bodyweight for age; WFH, weight for height.

mainly tertiary care centres (table 4), which may influence the overall prevalence.[18] In these studies various criteria were used to define acute and chronic malnutrition. We used the WHO criteria for defining malnutrition.[19] The likelihood of malnutrition was defined using a cut-off point of −2 SD. To compare data from other studies equivalent criteria for SD scores <−2 for weight for height or height for age should be used.

There are also some important weaknesses of this study. First, anthropometric measurements were performed by many observers on the three consecutive days. Thus, inter-observer and intra-observer variability may influence the results. Second, we were not able to check weighing scales and radiometers on the precise accuracy. Third, we did not take into account special growth curves for children with a chromosomal disorder or special growth curves for non-white children. None of the previously cited studies accounted for these issues, but one should be aware that prevalence rates of acute and chronic malnutrition might be slightly different.

The prevalence rate of 11% acute malnutrition that we found in The Netherlands is equivalent to other studies. Recently published prevalence data in Germany, France, UK, the US and Brazil show percentages varying between 6% and 19% (table 4). We found no difference in acute malnutrition between academic and general hospitals. In previous studies risk groups for acute malnutrition were children with multiple diagnoses, mental retardation, chromosomal disorders, infectious diseases and cystic fibrosis.[7 15] In our study the highest prevalence for acute malnutrition was seen in children admitted for gastrointestinal disorders. It should, however, be noticed that because of the non-uniform classification into disease categories used in various studies, it is difficult to accurately compare such prevalence data. In contrast to previous studies, we performed multivariate analysis, which enabled us to adequately identify risk groups for malnutrition. Children with an underlying disease showed a higher prevalence rate for acute malnutrition (14%) but this was not significantly different from children without an underlying disease. We did not find a difference in the prevalence of acute malnutrition among different age groups, whereas in previous studies the highest prevalence was found in infants and young children under 5 years of age.[6 15]

Chronic malnutrition in hospitalised children has only been reported in a few studies, with prevalence rates varying from 8–18%.[6 7 14] We found a prevalence of 9% and both underlying disease and non-white ethnicity were significantly related to a higher prevalence. The high prevalence of chronic malnutrition of specific groups of children with an underlying disease was also reported recently in children with neurological, cardiac and renal diseases.[20–24] Concerning the high prevalence of chronic malnutrition in non-white children we have to address to the fact that we did take into account special growth curves for these children. This might give an overestimation of the prevalence of chronic malnutrition.

Our study shows that children with acute malnutrition on admission stayed on average 45% longer in the hospital than children without such malnutrition. Relations between nutritional status and outcome measures such as hospital stay have mainly been described in adult patients,[25] not in children. Only recently Secker *et al* showed an association between a poorer preoperative nutritional status of surgical children and a higher risk of nutrition-associated complications and prolonged hospitalisation.[26]

Our study protocol included weight measurement at discharge, but this was only performed in 60% of children with a hospital stay >4 days. This latter finding points to an apparent lack of awareness on the need to screen nutritional status also at discharge. In those children measured at discharge 3% showed a weight loss of >5%, in 65% no weight loss was found and children with acute malnutrition on admission did not lose more weight during admission than children without malnutrition. These findings are in contrast to a study done in a tertiary hospital in Paris; from the 296 studied children 63% lost >2% and 17% lost >5% of weight during admission.[2] Reasons for this difference might be that compared to our study the group of children in Paris was younger (15 months vs 3.5 years) and had a longer mean hospital stay (mean 7 days vs median 2 days) with a higher percentage of children with a prolonged hospital stay (>5 days 65% vs >4 days 24%).

Our findings have major implications for clinicians and policymakers. All clinicians should be aware of the considerable group of children who have malnutrition on admission and the fact that this group stays significantly longer in the hospital. Clinicians have to act upon this knowledge by optimising nutritional support. In order to improve the standard of care and be informed about the problem of malnutrition, all hospitals should have a policy concerning screening and treatment of children who are malnourished on admission or at risk. As from 1 January 2008, the Dutch government has obliged all hospitals to screen for malnutrition in all hospitalised children on admission and to show the results of treatment of malnutrition on day 4 of admission.

Future research should focus on multicentre nutritional intervention studies to show the possible beneficial effect of treating malnutrition on nutritional status, morbidity and mortality.

Acknowledgements: Our thanks go to all the participating children and their parents for their cooperation, as well to all the participating hospitals, their contact people and the nursing and medical staff for performing the measurements and administering the questionnaire and to the seven students, who were prepared to go to all academic hospitals to assist the contact people and collect the forms.
The participating hospitals and coordinating physicians were: VU medical centre, Amsterdam, M van der Kuip and S van der Schoor; Emma Children's Hospital AMC, Amsterdam, C Jonkers and A Kindermann; University Medical Centre Groningen, Beatrix Children's Hospital, Groningen, HA Koetse; Leiden University Medical Centre,

Leiden, J Schweizer; University Hospital Maastricht, Maastricht, K Klucovska and E van Heurn; Wilhelmina Children's Hospital, University Medical Center Utrecht, G Visser; Medical Centre Alkmaar, Alkmaar, EK George; Flevo hospital, Almere, JM Deckers, Kocken; Meander Medical centre, Amersfoort, R Nuboer and NL Ramakers, van Woerden; Slotervaart Hospital, Amsterdam, JHM Budde; Gelre Hospital, Apeldoorn, MH Rövekamp; Wilhelmina Hospital, Assen, Y Bult and G Gonera; Amphia Hospital, Breda, SA de Man and R van Beek; IJsselland Hospital, Capelle a/d IJssel, HAA Damen, M Steijn and I Onvlee; Reinier de Graaf Gasthuis, Delft, MW Hekkelaan, Wesselink and JO Wishaupt; St Gemini Hospital, Den Helder, SE Barten; Slingeland Hospital, Doetinchem, MWM Eling; Albert Schweitzer Hospital, Dordrecht, ED de Kleijn; Catharina Hospital, Eindhoven, T Hendriks; Oosterschelde Hospital, Goes, EJA Gerritsen and L Gerling; Beatrix Hospital, Gorinchem, WAR Huijbers and M Evera, Preesman; HAGA hospital, Juliana Children's Hospital, The Hague, RH Lopes Cardozo; Hospital St Jansdal, Harderwijk, KJ Oosterhuis and J Hagendoorn; Hospital De Tjongerschans, Heerenveen, SM van Dorth; Elkerliek Hospital, Helmond, WEA Bolz and HGF Brouwer; Jeroen Bosch Hospital, 's Hertogenbosch, JH Hoekstra and E de Vries; Bethesda Hospital, Hoogeveen, AJ Stege; Medical Centre Leeuwarden, Leeuwarden, J Uitentuis; IJsselmeer Hospitals, Lelystad, WB Hofstra and H Vogt; Canisius, Wilhelmina Hospital, Nijmegen, BA Semmekrot and R Verlaak; Hospital Bernhoven, Oss, MJ Louwers; Maasland Hospital, Sittard, AC Engelberts; Ruwaard van Putten Hospital, Spijkenisse, D Birnie and M Vielvooye; Zorgsaam Hospital de Honte, Terneuzen, UI Fränkel; Tweesteden Hospital, Tilburg, JW Bonenkamp; Diakonessenhuis, Utrecht, WJ de Waal; Mesos Medical Centre loc Oudenrijn, Utrecht, HE Blokland, Loggers; Hospital Bernhoven, Veghel, AE Sluiter and W vd Broek; St Jans, Gasthuis, Weert, EM Kerkvliet and C Oud; St Lucas Hospital, Winschoten, B Auffarth, Smedema; Lange Land Hospital, Zoetermeer, JCD Brevoord; Gelre Hospitals, Zutphen, HFH Thijs; Princess Amalia Children's Clinic, Isala Clinic, Zwolle, A Molendijk and J Bekhof.

The participating students were N Kruijer, P Kramer, C Alingh, A Kerver, S vd Oord, H Zwart and W Roest.

Funding: Nutricia Nederland BV, Zoetermeer, The Netherlands: no role in the study, researchers independent from funders.

Competing interests: None.

Provenance and peer review: Not commissioned; externally peer reviewed.

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Arch Dis Child 2010 95: 141-145 originally published online May 3, 2009
doi: 10.1136/adc.2008.157255