# Prevalence of undernutrition in Japanese pediatric patients on admission: Comparison of tertiary, acute-care, and rehabilitation hospitals

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**Running title:** Undernutrition in hospitalized pediatric patients

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## ABSTRACT

**Background and Objectives:** There exist many studies in Western countries dealing with pediatric nutritional assessment on admission, but those in Asian countries are comparatively limited. This study aimed at clarifying the prevalence of undernutrition in 3 Japanese pediatric hospitals, especially focusing on their different characteristics. **Methods and Study Design:** Study participants included 313 patients aged 1–17 years admitted to a tertiary hospital (175 patients), an acute-care hospital (99 patients), or a rehabilitation hospital (39 patients). On admission, body height, weight, and serum albumin were measured. BMI was calculated by dividing the weight (kg) by the square of height (m). Patients exhibited undernutrition on account of BMI z-score <−2, weight-for-height (W/H) <90%, height-for-age (H/A) <95%, or albumin <3.5 g/dL. **Results:** The overall prevalence of undernutrition was 53.0%. Among 4 nutritional measures, the prevalence was highest in H/A (33.9%), followed by W/H (26.8%), BMI z-score (17.6%) and albumin (12.8%). A rehabilitation hospital exhibited significantly higher prevalence than that in a tertiary- or acute-care hospital. By the classification of International Statistical Classification of Diseases and Related Health Problems-10, neurological diseases and congenital anomalies showed higher prevalence among the disease categories which had the number of enrolled patients more than twenty. **Conclusions:** This study indicates that hospital characteristics and inpatient disease categories are important in the admission evaluation of the likelihood of undernutrition. These observations require consideration by hospital physicians in paediatric nutritional diagnosis and management.


**Key Words: undernutrition, hospitalized children, BMI, Waterflow classification, albumin**



## INTRODUCTION

Undernutrition is an important factor in predicting the prognosis of hospitalized children. It is thought to be associated with several clinical outcomes, including the length of hospital stay, infectious complications, and readmission rates.[1-3] Since undernutrition can be observed on admission, during hospitalization, and after discharge, continuous monitoring of nutritional status and intervention are required. Based on this notion, the implementation of nutrition support teams in pediatric units has been recommended.[4] At present, nutritional assessment based on anthropometry is the most acceptable method for evaluating a nutritional status in pediatric patients.[5,6] Nutritional screening tools such as STAMP, STRONGkids, and PYMS are thought to be useful to predict a nutritional risk, particularly on admission.[7,8] At some instances, biochemical biomarkers, such albumin or prealbumin, have been included in screening procedures. [9-10]

Prevalence of undernutrition in pediatric patients on admission has been reported extensively in studies undertaken in Western countries. Using several anthropometric measures, these studies reported that the prevalence of undernutrition varied between 5.8 and 27.2%.[1-3,11-16] On the other hand, the reports from the rest of the world, i.e. Brazil,[17] Thailand,[9] Iran,[18] Vietnam[19] and Turkey,[20] demonstrated slightly higher prevalence ranging from 10.0 to 55.0%. As for East Asia, we can find only one largescale study presented by Cao et al. in China,[21] but this investigation focused on the nutritional screening using STRONGkids rather than the anthropometric measures. Reasons for such a wide range of prevalence among different studies may be attributed to the differences in study years, patients' age, countries, anthropometric measures and hospital characteristics. Among these factors, in most previous studies, hospital characteristics were described simply as "tertiary" or "general" without descriptions of the patient details and distribution of the diagnosis. Although in adult inpatients, the disease category classified by the International Statistical Classification of Diseases and Related Health Problems (ICD)-codes, was demonstrated to play a pivotal role in the prevalence of malnutrition diagnosis.[22,23] Therefore, precise description of the characteristics of participating hospitals, and patients' disease category is necessary for comparing the prevalence of undernutrition on admission among different studies.

Based on a review of the international literature, the present study aimed to delineate the prevalence of undernutrition on admission in Japanese pediatric patients. The study specifically pays attention to the difference of undernutrition recorded among 3 hospitals that have varying patients' characteristics.

## MATERIALS AND METHODS

### *Study design and subjects*

This study was conducted between July and December 2015 using data from patients admitted to the pediatric departments in 3 different hospitals: Kyoto University Hospital (a tertiary hospital), Kyoto Katsura Hospital (an acute-care hospital), and Todaiji Medical and Educational Center (a rehabilitation hospital). These departments do not accept children admitted primarily for the purpose of surgical treatment. The pediatric department at Kyoto University Hospital accepts children mainly referred from primary or secondary clinics. Kyoto Katsura Hospital is a regional hospital in the southern part of Kyoto city. Its pediatric ward accepts patients with acute illnesses via outpatient or emergency clinics. The average length of hospital stay in 2014 was within 3 days. Todaiji Medical and Educational Center accepts pediatric patients with mental or physical disabilities mainly due to cerebral palsy or congenital anomalies. Cases from several patient typologies were excluded from this study based on 3 criteria: when patients were aged less than one year; when they lacked data concerning height, weight, or serum albumin on admission; or when they were critically ill and directly admitted to an intensive care unit. After exclusions, 313 patients were enrolled in the study, including 175 patients at Kyoto University Hospital, 99 at Kyoto Katsura Hospital, and 39 at Todaiji Medical and Educational Center. The details of patients, such as gender, age, and diagnosis are presented in Table 1. The diagnosis was made by a chief physician and was classified according to ICD-10 codes. This project was approved by the ethical and epidemiological committee at Nara Women's University.

***Measurement of body height, weight, and serum albumin***

Body height and weight on admission were measured by well-trained nurses at each hospital. Height was measured to the nearest 0.1 cm, and weight was measured to the nearest 0.1 kg. Since most patients in the rehabilitation hospital had severe spinal curvatures, their height was measured by the two-split method, in which the whole body was divided into 2 parts and measured. In such cases, measurements were taken from the top of the head to the greater trochanter and from the greater trochanter to the planta.[24] BMI was calculated by dividing the body weight (kg) by the square of height (m).Serum albumin was measured by an improved bromocresol purple (BCP) method using an automatic blood analyzer in venous blood drawn on admission.

***Definition of undernutrition***

Patients who fulfilled one of the following criteria were defined as exhibiting undernutrition: BMI z-score <−2, Waterlow classification: weight-for-height (W/H) <90% or height-for-age (H/A) <95%,[25] or albumin concentrations <3.5 g/dL. As the standard growth charts for evaluating BMI z-scores, W/H and H/A, we used the official Japanese children's anthropometric data for children age 5 and over published by the Ministry of Education, Culture, Sports, Science and Technology,[26] and for those age 4 and under published by the Ministry of Health, Labor and Welfare.[27]

***Statistical analysis***

Differences in recorded variables were examined using the Chi-squared test. Correlations among nutritional measures were evaluated by the Pearson analysis. All statistical analyses were performed using Excel Statistics (Version 2012). *p*-values less than 0.05 were considered significant.

## RESULTS

***Prevalence of undernutrition based on hospitals, gender, age, and disease category***

In total, 166 patients (53.0%) were diagnosed with undernutrition since they had at least 1 abnormal nutritional measure (Table 2). Prevalence increased significantly with age (12~14 and 15~17 years) ($p<0.001$), but there was not any sex difference ($p=0.071$). Prevalence of undernutrition was significantly higher in the rehabilitation hospital than in the tertiary or acute-care hospitals ($p<0.001$), while no statistical difference was found between the tertiary and acute-care hospitals ($p=0.55$). In addition, prevalence of undernutrition was found to vary considerably among the ICD-10 disease category, from 83.3% in gastrointestinal diseases to 0% in skin diseases.

***Prevalence of undernutrition in 4 nutritional measures***

Among 4 nutritional measures in all patients, the prevalence of undernutrition was the highest in H/A (33.9%), followed by W/H (26.8%), BMI z-score (17.6%), and serum albumin (12.8%) (Table 3). As shown in Table 3, this trend was similar among 3 different hospitals. However, the prevalence of undernutrition on BMI z-score ($p<0.0001$), H/A ($p<0.0001$) and W/H (p=0.0004) was statistically higher in the rehabilitation hospital compared to the tertiary or acute-care hospitals except for albumin ($p=0.30$). The difference in prevalence of undernutrition in 4 measures between the tertiary and acute-care hospital was not statistically significant (*p* values for BMI z-score, 0.42; H/A, 0.93; W/H, 0.17; albumin, 0.83).

Prevalence of undernutrition among different disease groups classified by ICD-10

The difference in prevalence of undernutrition among 6 representative disease categories was significant. The highest level of undernutrition was found in the neurological diseases (72.9%) and the lowest level was recorded for the infectious diseases (38.5%) (Table 4). Among 4 nutritional measures, the prevalence of BMI z-score and H/A was highest in neurological diseases, whereas W/H was highest in neoplasms, and albumin was highest in respiratory diseases.

***Correlation of 4 nutritional measures in all patients***

As indicated in Table 5, a significant positive correlation was found between BMI z-score and W/H ($p$<0.0001). In addition, albumin levels were significantly correlated positively with BMI z-score ($p$=0.0004), H/A ($p$=0.009), and W/H ($p$<0.0001).

**DISCUSSION**

Hospitalized children may experience changes in their nutritional status from admission to discharge. An initial nutritional assessment is important since it comprises the basic data required for subsequent nutritional evaluation during hospitalization. The association of undernutrition on admission with length of hospital stay or other unfavorable outcomes suggests the importance of assessing a nutritional status on admission.[1-3,28]

At present, there are not any commonly accepted anthropometric measures for evaluating the nutritional status in pediatric patients. Many investigators, especially those in Western countries, have recommended and used BMI z-scores <−2 based on the World Health Organization (WHO) reference growth chart.[3,29] However, Joosten and Hulst warned that the use of WHO growth reference data had the possibility of overestimating or underestimating undernutrition compared with the use of country specific growth reference information.5 Considering that Japanese children tend to be shorter and thinner than children in Western countries, we used the Japanese growth chart for calculating BMI z-scores.[26,27] In total, 55 patients (17.6%) exhibited BMI z-scores <−2.0. Based on this measure, prevalence of undernutrition appears to be higher than in Western countries (5.8%–10.2%),[3,13,16] but almost identical to the report by Cao et al. (14.5%).[21] Other widely used anthropometric measures are H/A and W/H, expressed by either their z-scores[12,14,18,19] or percentages of the standard values (Waterlow classification).[9,11,20] In this study, we used Waterlow classification since we already had the data from a normal pediatric population.[25] Our overall findings concerning prevalence of undernutrition based on H/A (33.9%) and W/H (26.8%) were similar to those in the report by Hendricks et al.[9] It is noteworthy that a rehabilitation hospital had higher prevalence on both measures and higher numbers of patients with moderate or severe undernutrition according to Waterlow classificsation.

There are arguments for and against using serum albumin as a biomarker for nutritional assessment.[10,30] The present study indicates that the overall prevalence of undernutrition was 12.8% as judged by hypo-albuminemia (< 3.5 g/dL). The order of undernutrition prevalence among different hospitals was as follows, rehabilitation, tertiary, and acute-care hospitals, but the difference in prevalence by a hospital type was not significant. It is notable that albumin concentrations correlated positively with 3 anthropometric measures. Agostoni et al demonstrated an inverse association between albumin levels and length of hospital stay.[13] Therefore, although not sensitive enough to identify patients with undernutrition, we contend that albumin can still be a useful biomarker of nutritional status in pediatric patients.

The present study indicates that prevalence of undernutrition was significantly higher in a rehabilitation hospital than in tertiary and acute-care hospitals. The higher prevalence identified in a rehabilitation hospital is presumably associated with the different distribution of disease categories. Patients in a rehabilitation hospital mainly consisted of those with neurological diseases (79.5%) and congenital anomalies (12.8%). The former disease category mainly consisted of cerebral palsy in the present study is considered to be a risk factor for malnutrition because of feeding difficulties, frequent gastrointestinal symptoms, and/or altered energy metabolism.[24,31] On the other hand, overall prevalence of undernutrition was similar between the tertiary hospital and the acute-care hospital. This observation was unexpected, since patients at the tertiary hospital might have more underlying diseases than those in the acute-care hospital. However, Huysentruyt et al have reported that no significant difference was found between secondary and tertiary hospitals regarding the prevalence of chronic undernutrition as judged by H/A.[1] Whether there is the difference of prevalence of undernutrition between a tertiary hospital and an acute-care or secondary hospital waits for a further investigation by increasing enrolled hospitals and patients.

There are several limitations in the present study. First, the nutritional assessment was only undertaken at the time of admission. A concurrent study of patients' outcomes, such as length of hospital stay and infectious events, is desirable. Second, we selected only 3 hospitals as representatives of institutions with different characteristics. In future studies, the number of participating hospitals should be increased to avoid selection bias and to increase representation. Finally, since this a retrospective study, approximately 10%–15% of admitted patients were excluded due to the lack of at least one data parameter. In spite of these limitations, the present study has 2 major advantages. First, when nutritional assessment of hospitalized children in North-East Asian countries is still limited, we have identified important data on prevalence of undernutrition on admission using 3 anthropometric measures and albumin concentrations. Second, hospital characteristics, particularly the disease category of inpatients, were taken into consideration. We contend that the characteristics of hospitals should be taken into consideration when analyzing the nutritional status of pediatric inpatients and planning nutritional intervention. Since this is a retrospective observational study, we can't clarify the relative usefulness of each parameter. At present, however, we recommend to use one of anthropometric parameters, i.e. BMI-score or W/H, and albumin in combination for evaluating the nutritional status of pediatric patients.

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## CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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**Table 1.** Characteristics of patients at 3 different hospitals

| Hospitals | Tertiary | Acute-care | Rehabilitation | Total |
|---|---|---|---|---|
| Number of patients | 175 | 99 | 39 | 313 |
| Gender | | | | |
| Male | 91 (52.0)† | 54 (54.5) | 21 (53.8) | 166 (53.0) |
| Female | 84 (48.0) | 45 (45.5) | 18 (46.2) | 147 (47.0) |
| Age (years) | | | | |
| 1~ | 25 (14.3) | 23 (23.2) | 1 (2.6) | 49 (15.7) |
| 2~5 | 62 (35.4) | 44 (44.4) | 10 (25.6) | 116 (37.1) |
| 6~11 | 54 (30.9) | 19 (19.2) | 11 (28.2) | 84 (26.8) |
| 12~14 | 21 (12.0) | 7 (7.1) | 11 (28.2) | 39 (12.5) |
| 15~17 | 13 (7.4) | 6 (6.1) | 6 (15.4) | 25 (7.9) |
| Disease category‡ | | | | |
| Infectious diseases (A) | 5 | 21 | 0 | 26 |
| Neoplasms (C) | 33 | 0 | 0 | 33 |
| Blood and immunologic diseases (D) | 10 | 4 | 0 | 14 |
| Endocrine and metabolic diseases (E) | 5 | 1 | 1 | 7 |
| Psychologic diseases | 3 | 0 | 0 | 3 |
| Neurological diseases (G) | 16 | 1 | 31 | 48 |
| Circulatory diseases ( I) | 2 | 0 | 0 | 2 |
| Respiratory diseases (J) | 4 | 51 | 0 | 55 |
| Gastrointestinal diseases (K) | 4 | 0 | 2 | 6 |
| Skin diseases (L) | 1 | 2 | 0 | 3 |
| Muscle and bone diseases (M) | 3 | 6 | 0 | 9 |
| Genitourinary diseases (N) | 1 | 2 | 0 | 3 |
| Perinatal disorders (P) | 10 | 0 | 0 | 10 |
| Congenital anomalies (Q) | 40 | 0 | 5 | 45 |
| Unclassified diseases (R) | 21 | 11 | 0 | 32 |
| Food allergy (S) | 17 | 0 | 0 | 17 |

†Numbers in parentheses indicate the percentages.
‡Classification of diseases is based on ICD-10.

**Table 2.** Prevalence of undernutrition according to gender, age, hospitals and disease category

| Nutritional status | Normal nutrition | Undernutrition | Total | *p* values* |
|---|---|---|---|---|
| Number of patients | 147 (47.0)† | 166 (53.0) | 313 | |
| Gender | | | | 0.071 |
| Male | 70 (42.2) | 96 (57.8) | 166 | |
| Female | 77 (52.4) | 70 (47.6) | 147 | |
| Age (years) | | | | <0.001 |
| 1~ | 28 (57.1) | 21 (42.9) | 49 | |
| 2~5 | 52 (44.8) | 64 (55.2) | 116 | |
| 6~11 | 47 (56.0) | 37 (44.0) | 84 | |
| 12~14 | 11 (28.2) | 28 (71.8) | 39 | |
| 15~17 | 9 (36.0) | 16 (64.0) | 25 | |
| Hospitals | | | | <0.001 |
| Tertiary | 95 (54.3) | 80 (45.7) | 175 | |
| Acute care | 50 (50.5) | 49 (49.5) | 99 | |
| Rehabilitation | 2 (5.1) | 37 (94.9) | 39 | |
| Disease category‡ | | | | |
| Infectious diseases (A) | 16 (61.5) | 10 (38.5) | 26 | |
| Neoplasms (C) | 14 (42.4) | 19 (57.6) | 33 | |
| Blood and immunologic diseases (D) | 7 (50.0) | 7 (50.0) | 14 | |
| Endocrine and metabolic diseases (E) | 3 (42.9) | 4 (57.1) | 7 | |
| Psychologic diseases | 1 (33.3) | 2 (66.7) | 3 | |
| Neurological diseases (G) | 13 (27.1) | 35 (72.9) | 48 | |
| Circulatory diseases ( I) | 1 (50.0) | 1 (50.0) | 2 | |
| Respiratory diseases (J) | 27 (49.1) | 28 (50.9) | 55 | |
| Gastrointestinal diseases (K) | 1 (16.7) | 5 (83.3) | 6 | |
| Skin diseases (L) | 3 (100) | 0 (0) | 3 | |
| Muscle and Bone diseases (M) | 8 (88.9) | 1 (11.1) | 9 | |
| Genitourinary diseases (N) | 2 (66.7) | 1 (33.3) | 3 | |
| Perinatal disorders (P) | 2 (20.0) | 8 (80.0) | 10 | |
| Congenital anomalies (Q) | 17 (37.8) | 28 (62.2) | 45 | |
| Unclassified diseases (R) | 18 (56.3) | 14 (43.7) | 32 | |
| Food allergy (S) | 14 (82.4) | 3 (17.6) | 17 | |

†Numbers in parentheses indicate the percentages.
‡Disease category was classified by ICD-10.

**Table 3.** Prevalence of undernutrition as measured by 4 different nutritional measures at 3 different hospitals

| Hospitals | Tertiary | Acute care | Rehabilitation | Total | *p* values[*] |
|---|---|---|---|---|---|
| Number of patients | 175 | 99 | 39 | 313 | |
| BMI z-score | | | | | <0.0001 |
| undernutrition[†] | 23 (13.1)[***] | 9 (9.1) | 23 (59.0) | 55 (17.6) | |
| normal nutrition | 152 (86.9) | 90 (90.9) | 16 (41.0) | 258 (82.4) | |
| H/A | | | | | <0.0001 |
| undernutrition | 49 (27.9) | 29 (29.3) | 28 (71.8) | 106 (33.9) | |
| severe | 9 (5.1) | 3 (3.0) | 16 (41.0) | | |
| moderate | 9 (5.1) | 5 (5.1) | 6 (15.4) | | |
| mild | 31 (17.7) | 21 (21.2) | 6 (15.4) | | |
| normal nutrition | 126 (72.1) | 70 (70.7) | 11 (28.2) | 207 (66.1) | |
| W/H | | | | | 0.0004 |
| undernutrition | 46 (26.3) | 18 (18.2) | 20 (51.3) | 84 (26.8) | |
| severe | 1 (0.6) | 0 (0) | 6 (15.5) | | |
| moderate | 16 (9.1) | 5 (5.1) | 7 (17.9) | | |
| mild | 29 (16.6) | 13 (13.1) | 7 (17.9) | | |
| normal nutrition | 129 (73.7) | 81 (81.8) | 19 (48.7) | 229 (73.2) | |
| Albumin | | | | | 0.30 |
| undernutrition | 21 (12.0) | 11 (11.1) | 8 (20.5) | 40 (12.8) | |
| normal nutrition | 154 (88.0) | 88 (88.9) | 31 (79.5) | 273 (87.2) | |

H/A: height-for-age; W/A: weight-for-age.
[*]The statistical difference was evaluated by the Chi-squared test.
[†]Definitions of undernutrition for each measure is BMI z-score <-2, H/A <95%, W/H <90%, or albumin <3.5g/dL.
[‡]Numbers in parentheses indicate the percentages.

**Table 4.** Prevalence of undernutrition by 4 nutritional measures in different disease category

| ICD-10 Classification | Total patients | Positive patients† | BMI z-score | H/A | W/H |
|---|---|---|---|---|---|
| Infectious diseases (A) | 26 | 10 (38.5) | 2 (7.7)‡ | 6 (23.1) | 7 (26.9) |
| Neoplasms (C) | 33 | 19 (57.6) | 7 (21.2) | 12 (36.4) | 13 (39.4) |
| Blood and immunologic diseases (D) | 14 | 7 (50.0) | 1 (7.1) | 6 (42.9) | 1 (7.1) |
| Neurological diseases (G) | 48 | 35 (72.9) | 21 (43.8) | 27 (56.3) | 19 (38.6) |
| Respiratory diseases (J) | 55 | 28 (50.9) | 6 (10.9) | 19 (34.5) | 10 (18.2) |
| Congenital anomalies (Q) | 45 | 28 (62.2) | 8 (17.8) | 18 (40.0) | 12 (26.7) |

H/A: height-for-age; W/H: weight-for-height.
†Positive patients indicate those who showed at least one abnormal value in 4 nutritional measures. The statistical difference among diseases in different categories was evaluated by the Chi-squared test ($p$=0.024).
‡Numbers in parentheses indicate the percentages

**Table 5.** Correlation of nutritional measures in all patients (n=313)

| | Correlation efficiency | *p* values* |
|---|---|---|
| BMI z-score vs H/A | 0.036 | 0.53 |
| BMI z-score vs W/H | 0.75 | <0.0001 |
| BMI z-score vs Albumin | 0.21 | 0.0004 |
| H/A vs W/H | -0.01 | 0.86 |
| H/A vs Albumin | 0.24 | 0.009 |
| W/H vs Albumin | 0.32 | <0.0001 |

H/A: height-for-age; W/H: weight-for-height.
*Correlation efficiency was evaluated by the Pearson analysis.