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# Prevalence of Malnutrition, Obesity and Nutritional Risk of Australian Paediatric Inpatients: A National One Day Snapshot

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# Prevalence of Malnutrition, Obesity and Nutritional Risk of Australian Paediatric Inpatients: A National One Day Snapshot

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Short Title: Nutritional Status of Australian Paediatric Inpatients

Non standard abbreviations: PYMS Paediatric Yorkhill Malnutrition Score, ATSI Aboriginal and Torres Strait Islander.

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Abstract

*Aim*: Low prevalence rates of malnutrition at 2.5% to 4% have previously been reported in two tertiary paediatric Australian hospitals. The current study is the first to measure ~~both~~ the prevalence of malnutrition, obesity and nutritional risk of paediatric inpatients in multiple hospitals throughout Australia.

*Methods*: Malnutrition, ~~and~~ obesity ~~prevalence~~ and nutritional risk prevalence were investigated in 832 and 570 paediatric inpatients respectively in 8 tertiary paediatric hospitals and 8 regional hospitals across Australia on a single day. Malnutrition and obesity prevalence was determined using z scores and BMI percentiles. High nutritional risk was determined as a Paediatric Yorkhill Malnutrition Score of 2 or more.

*Results*: The prevalence of malnourished, wasted, stunted, overweight and obese paediatric patients was 15%, 13.8%, 11.9%, 8.8% and 9.9% respectively. Patients who identified as Aboriginal and Torres Strait Islander were more likely to have lower height for age z scores ($p < 0.01$) however BMI and weight for age z scores were not significantly different. Children who were younger, from regional hospitals or with a primary diagnosis of cardiac disease or cystic fibrosis had significantly lower anthropometric z scores ($p=0.05$). Forty-four percent of patients were identified as at high ~~nutrition~~ nutritional risk and requiring further nutritional assessment.

*Conclusions:* The prevalence of malnutrition and nutritional risk of Australian paediatric inpatients on a given day was much higher when compared to the healthy population. In contrast, the proportion of overweight and obese patients was less.

Keywords: Nutrition, Malnutrition, Children, Hospital, Australia, Obese.

What is already known on this topic.

- Nutritional status of paediatric inpatients impacts on their immune function, physical and cognitive development and clinical outcomes.
- Single centre studies in Australian hospitals have reported malnutrition prevalence~~rates~~ of paediatric inpatients to be between 2.5% and 4%.
- A study from the United Kingdom has found 10~~59~~% of paediatric inpatients to be at high nutritional risk.

What this paper adds.

- The prevalence of malnutrition~~nutritional status~~ and ~~nutrition~~ nutritional risk of paediatric inpatients in multiple tertiary and regional hospitals across Australia is relatively high at 15% and 44% respectively.
- Children who were younger, from regional hospitals or with a primary diagnosis of cardiac disease or cystic fibrosis are more likely to be malnourished and should be targeted for nutrition intervention.
- Patients who identified as Aboriginal and Torres Strait Islander were more likely to have lower height for age z scores.

Introduction

It is well known that the nutritional status of children impacts on their immune function, physical and cognitive development and clinical outcomes (1-4). Therefore, it is critically important to identify the prevalence of malnutrition and obesity of paediatric inpatients and those at ~~nutrition risk~~nutritional risk to develop and implement timely and appropriate nutrition intervention and treatment plans, support future health policy development and assist in resource planning.

The malnutrition and ~~nutrition risk~~nutritional risk prevalence of paediatric inpatients has previously been reported between 2.5% and 19% in Europe, the United States, the United Kingdom and Australia (5-10). The majority of the malnutrition prevalence studies are limited to single site studies with the exception of one large multi site study from the Netherlands which found the highest malnutrition prevalence rate of 19% (10). Single centre studies in Australian hospitals measuring malnutrition rates of paediatric inpatients have reported relatively low rates between 2.5% and 4% (5, 6). Children who are overweight or obese also have an increased risk of mortality and morbidity when unwell (4). Prevalence of overweight and obesity in Australian paediatric inpatients has previously been reported to be between 22% and 25% (5, 6)

The ~~nutrition risk~~nutritional risk of a child predicts the likely hood of a child having or developing malnutrition and hence can indicate a need for nutrition intervention. Paediatric inpatients are at a high risk of developing malnutrition during admission which increases length of stay and the likelihood of

readmission (11). There are several validated paediatric ~~nutrition risk~~ nutritional risk screening tools described in the literature which have been shown to be effective in identifying children at risk of developing malnutrition (12-15). The Paediatric Yorkhill Malnutrition Score (PYMS) is a paediatric nutrition screening tool validated in both tertiary and regional hospitals. This tool was demonstrated to be highly effective in identifying children at risk of malnutrition and produced fewer false positives when compared to other screening tools which reduces the number of patients who would require further nutrition assessment ~~.~~ (15). PYMS has also undergone secondary validation against other published screening tools in children with inflammatory bowel disease and spinal cord injuries (16, 17).

The malnutrition, obesity and ~~nutrition risk~~nutritional risk prevalence of paediatric inpatients across Australian hospitals has not been studied and remains unknown. The present study expands on the existing, limited knowledge base, by determining the malnutrition, ~~and~~ obesity ~~prevalence~~ and ~~nutrition risk~~nutritional risk prevalence of paediatric inpatients in multiple tertiary and regional hospitals across Australia, and identifying demographic characteristics that may be associated with malnutrition, obesity and ~~nutrition risk~~nutritional risk.

## Materials and Methods

### *2.1 Patient population, recruitment and demographics*

All children from term age (corrected for gestational age up to 2 years of age) to 19 years of age who were inpatients in 16 Australian hospitals (8 tertiary

paediatric hospitals and 8 regional hospitals) at 1000 hours local time on the 7th of March, 2013 were considered for the study. Ineligibility criteria are detailed in Table 1.

Each site had a nominated site lead who co-ordinated data collection at the local level. To ensure consistency across sites, each site was given a study manual with detailed instructions. A data collection pack was allocated for each patient containing a study check-list, a script for introducing the study to carers and or patients, a data collection sheet and the PYMS screening tool. The data collection sheet included the patient's date of birth, gestational age, gender, Aboriginal and Torres Strait Islander (ATSI) status, primary diagnosis, reason for admission and identified if the patient met any exclusion criteria. This information was collected for all admitted patients. Patients identified as eligible then proceeded to anthropometric measurement and nutritional risk screening~~data collection.~~

Ethical and site specific approval was obtained from the ethics committee from each respective hospital. The ethics committees waived the requirement for formal consent however verbal consent was sought from the caregivers and patients could refrain from participation without consequences.

*2.2 Anthropometry and ~~nutrition risk~~nutritional risk*

Weight and height or length were measured using methods previously described by the WHO (18). Each site ensured scales and stadiometers were calibrated before the study. For children who were older than 2 years of age

and where a direct measure of height or length was not possible, height was estimated from knee height (19).

Body Mass Index (BMI) for age, height for age and weight for age z scores where calculated using WHO growth standards from 0 to 2 years of age (*www.who.int/childgrowth/standards/en*) and the United States Centre for Disease Control (CDC) 2000 reference population for 2 -20 years of age (*www.cdc.gov*). Malnutrition, wasting and stunting were defined as ~~≤ -~~≤ -2 z score for BMI for age, weight for age and height for age respectively (18). Obesity was defined according to Cole's internationally agreed standard cut off points for overweight and obese (20).

~~Nutrition risk~~Nutritional risk was determined using the PYMS for children > 12 months~~1 year~~ of age (15). The PYMS is a simple, validated scoring system to identify children who are at ~~nutrition risk~~nutritional risk. The components of the PYMS include~~s~~ calculation of BMI and comparison to cut offs, recent weight loss, recent change in oral intake and whether the patient's diagnosis or admission would affect ~~nutrition risk~~nutritional risk. The patients were given a score according to the criteria, a total score of 1 identified medium ~~nutrition risk~~nutritional risk and a total score of 2 or more identified high ~~nutrition risk~~nutritional risk and need for further nutrition assessment.

*2.3 Statistical analysis*

Data were analysed using IBM SPSS version 20 (IBM corporation, Somers, NY). Demographic, anthropometric, ~~nutrition risk~~nutritional risk characteristics and

prevalence were described using descriptive statistics. Chi-square was used to assess significant differences between eligible and non-eligible participants. Multiple linear regression was then used to investigate adjusted associations between nutritional risk and anthropometric measures~~nutritional status~~ and primary diagnosis, reason for admission, age, gender, hospital type and patients who identified as ATSI. The level of statistical significance was set at 5%.

## Results

### *3.1 Patients*

A total of 1175 patients were considered for the study, of which 832 were ~~e~~ ~~deemed~~ eligible for further measurement. The primary reasons for ineligibility were critical illness, unable to obtain an accurate weight or the patient or carer declining the measurement (Table 1). Table 2 shows the demographic characteristics of the eligible patients. The eligible group had significantly more females (53.8% vs 46.2%), more children with cystic fibrosis as a primary diagnosis (4.2% vs 0.6%) and a respiratory infection as their reason for admission (14.5% vs 7.6%) than the ineligible group. The ineligible group had significantly ($p<0.01$) more children with a surgical diagnosis as a reason for admission than the eligible group.

### *3.2 Anthropometry and Associations*

A total of 832 patients had anthropometric measurements taken. Table 3 describes the anthropometric measurements and z scores of the study

population. Twenty-four patients had height estimated from knee height. One hundred and twenty-two (15%) patients were malnourished, 113 (13.8%) were wasted and 97 (11.9%) were stunted (Table 4). Seventy-one children (8.8%) were found to be overweight and 80 (9.9%) obese.

Tables 5 and 6 presents~~summarise~~ the adjusted associations between patient characteristics, hospital type and z scores for ~~,~~ malnutrition, wasting, stunting, ~~nutrition risk~~nutritional risk and overweight/ obesity. Paediatric inpatients in~~of~~ regional hospitals were more than two-times more likely to be malnourished (p = 0.004) and wasted (p = 0.008), and were over 60% less likely to be overweight or obese (p = 0.002). There was a significant positive relationship between age and all anthropometric z scores. Patients who identified as ATSI were more likely to be shorter and were nearly three times more likely to be categorised as 'stunted' compared to those who did not identify as ATSI (p = 0.001). Weight z scores, BMI z scores~~, malnutrition~~, ~~nutrition risk~~nutritional risk and overweight or obesity were not significantly associated with ATSI status. Patients who had a primary diagnosis with a surgical origin were significantly more likely to have a higher BMI and weight for age z score, and were over three times more likely to be overweight or obese compared to children in the 'other diagnosis' category (p = 0.009). Children with a primary diagnosis of cardiac disease or cystic fibrosis had significantly lower anthropometric z scores with the exception of height for age z scores observed in the patients with cystic fibrosis. Those with a cardiac diagnosis were four times more likely to be malnourished and five times more likely to be wasted compared to those in the diverse 'other' category, while children diagnosed with cystic fibrosis were 99% less likely to be overweight or obese (p = 0.02) compared to the 'other' diagnosis group. Finally,

children had significantly lower BMI z scores if they were in the diverse 'other' category as a reason for admission. Examples of reasons for admission in this category included fractures, seizures and type 1 diabetes.

### *3.3 ~~Nutrition Risk~~Nutritional risk*

A smaller number of patients (N=~~total of~~ 570~~) patients~~ were assessed for ~~nutrition ris~~nutritional risk compared to patients who had anthropometric measures (N=832)~~k~~ due to ~~.p This is significantly less than the number of patients who had anthropometric data collected (n=872) primarily due to p~~atients who were <12 months of age being~~being~~ ineligible for assessment by PYMS. Seventy- two (12.8%) patients were below the BMI cut-off for a ~~nutrition risk~~nutritional risk score, 232 (40.7%) patients had a history of recent weight loss, 216 (36.0%) patients had reduced nutritional intake and 29 (4.8~~.0~~%) had no intake over the previous week. One hundred and eighty-three (30.5%) patients had a condition or reason for admission which would reduce their intake and/~~-~~or increase requirements and/~~-~~or increase losses for the proceeding week. Only ~~7~~7 ~~-~~(1.2%) patients had a condition or reason for admission that would~~e~~ result in no intake for at least the next week. Overall there were 251 (44%) patients defined as being at high ~~nutrition risk~~nutritional risk and requiring further nutrition assessment. Children with an oncology ~~-~~related (p=0.003) or gastroenterology ~~-~~related (p = 0.04) diagnosis were approximately two ~~-~~times more likely to be identified as 'at ~~nutrition risk~~nutritional risk' by the PYMS tool, compared to other children, while children diagnosed with cystic fibrosis were 65% less likely to be at ~~nutrition risk~~nutritional risk (p = 0.04)~~,~~ (Table 6).

## Discussion

This is the first study in which the prevalence of malnutrition, ~~and~~ obesity and ~~nutrition risk~~nutritional risk of paediatric inpatients in multiple Australian hospitals has been investigated. This nation-wide study provided a snapshot of the anthropometrics and ~~nutrition risk~~nutritional risk of Australian paediatric inpatients on a single day. ~~It provided c~~Comprehensive anthropometric data for over two thirds of admitted patients and complete ~~nutrition risk~~nutritional risk screening data for almost half of the inpatients in a majority of~~every~~ tertiary paediatric hospitals in Australia~~ with the exception of one~~ and several regional hospitals has been provided.

Within this study the overall prevalence of malnutrition in~~for~~ paediatric inpatients was 15%, 13.8% of patients were identified as being wasted and 11.9% of patients identified as stunted. A comparable study in a single tertiary paediatric Australian hospital of 157 children reported that 2.5% were malnourished, 4.5% were wasted and 8.9% stunted (5). These findings are in agreement with a previous single site study in another tertiary paediatric Australian Hospital (6). Both hospitals in the earlier studies were included as sites in the current study and found an increase in prevalence of malnutrition, wasting and stunting in the current study compared to previously. This is possibly due to differing study design in regards to data collection periods and exclusion criteria resulting in patients that were younger and sicker and more likely to be malnourished being included in the current study population.

Our study observed similar malnutrition prevalence rates to a Dutch national study of paediatric inpatients in 44 hospitals which reported a malnutrition prevalence of 19%. (10). A wide variety of malnutrition prevalence rates have been reported by previous studies ranging from 2.5% to 19% (5-10). The heterogeneity of the criteria used to define malnutrition, the patient sampling methods, subject age and hospital type make these studies difficult to compare. As previously identified this highlights the need for agreed and evidence based criteria for the diagnosis of malnutrition and risk of~~for~~ malnutrition (21).

Despite the difficulty in comparing the results to previous studies we observed a significant increase in the proportion of children in hospital who are malnourished compared to the free living healthy population. This study found 15% of children had a BMI z score of ≤ -2 compared to 2.3% in a normally distributed healthy population. The number of children with BMI z score of ≤ -3 was 5.5% with normal distribution being 0.14%. The presence of children with a BMI z score of ≤ ~~-~~–3 is concerning as the current clinical capabilities and tools of a skilled workforce should prevent any child from developing severe malnutrition despite being unwell ~~from severe malnutrition~~. Based on the international cut ~~-~~ off point of ≤ -2 z score to classify malnutrition, this study identified that children with a cardiac or cystic fibrosis diagnosi~~i~~s, and those who were inpatients in regional hospitals, were significantly more likely to be malnourished.

It has been identified that there is a lack of a uniform definition for malnutrition for paediatric inpatients which may directly support the under recognition of its prevalence (22). The statistical methods used to define malnutrition for this study employed recommendations by WHO (16). In Australia, the current Diagnosis Related Groups (DRG) reimbursement criteria to define malnutrition is a weight for age z score of ≤ -1 (23). If this were incorporated in the malnutrition definition for the current study 29.6% of the patients would have a diagnosis of malnutrition which would contribute substantially to financial reimbursement for hospitals.

This study found 18.7% of Australian paediatric inpatients to be overweight or obese where as population based studies report the prevalence to be around 24% (24). Prevalence of overweight and obesity in Australian paediatric inpatients has previously been reported to be between 22% and 25% (5, 6). These studies excluded children less than 2 years of age. Given the significant relationship between age and BMI z score, it is expected there would be significantly less overweight and obese children in this age category. Our findings suggested that children with a surgical -related diagnosis were over three times more likely to be overweight or obese.

To our knowledge, this is the first Australian study which has investigated and described the prevalence of malnutrition, obesity and nutritional risk~~nutritional status~~ of paediatric inpatients of ATSI descent. Children who identified as being of ATSI descent were more likely to be shorter than their peers, however no

difference in BMI or weight z scores was observed. Previously, it has been documented that in the healthy population, children who identify as ATSI are shorter than their non-ATSI counterparts, but have a similar average weight compared to the overall of the population of Australian children resulting in significantly increased BMI z scores (25, 26). The increased BMI z scores were not observed in the current study. This indicates that children who identify as ATSI and who are admitted to hospital are less likely to be overweight and obese than their peers. It is proposed that the low height for age z score is an indicator of chronic malnutrition (16). Similar findings have been observed in other studies where paediatric inpatients with non-white ethnicity have a significantly higher rate of chronic malnutrition (10). It is possible that the incidence of chronic malnutrition was over estimated in the ATSI group as population specific growth standards were not used for these children.

The multiple diagnoses and reason for admissions for the study population made it difficult to categorise resulting in almost half of the children allocated into the 'other' category. As previously described by other studies, children with a primary diagnosis of cardiac disease or cystic fibrosis were found to have a higher incidence of malnutrition when compared to other inpatients (11, 27, 28). Growth failure in these diagnosis groups has been found to be related to increased mortality which clearly emphasises the importance of disease specific targeted nutritional intervention (28, 29). This study also concluded that the groups of patients who had previously been reported at high nutrition risknutritional risk such as those with an oncological illnesses and gastro intestinal disease were not found to be significantly malnourished (22), however

these groups were significantly more likely to be identified as 'at ~~nutrition risk~~nutritional risk' compared to others.

Within the current study forty-four percent of patients were identified as being at ~~nutrition risk~~nutritional risk and requiring further nutrition~~al~~ assessment by the PYMS. Due to the nature of the PYMS assessment ~~of nutrition risk~~nutritional risk was limited to children > 12 months of age. The percentage of children identified as being at ~~nutrition risk~~nutritional risk is likely to be higher if infants were included. The primary contributors to ~~nutrition risk~~nutritional risk were no or reduced nutrition intake and recent weight loss highlighting the importance of being proactive in the prevention of the development of malnutrition and not simply relying on routine anthropometric measures ~~of anthropometric data of patients~~.

The aim of this study was to provide a comprehensive description of the prevalence of malnutrition, obesity and ~~nutrition risk~~nutritional risk of paediatric patients admitted to Australian hospitals on a given day. To ensure the study population was a representative sample, demographic data was collected on all inpatients. Some discrepancies were found between eligible and ineligible patients with respect to gender, reason for admission and primary diagnosis. Gender and ~~a~~ respiratory infection as a reason for admission, were found to have no effect on malnutrition and obesity prevalence ~~nutritional statush~~ ~~h~~owever patients with a surgical reason for admission were more likely to be taller and patients with cystic fibrosis malnourished.~~.~~ Furthermore~~The ineligible~~

~~group being significantly more likely to have a surgical reason for admission may have impacted on height for age z score.~~ , the categorisation of surgical patients used in this study is broad and the type of surgery ~~Th~~would have impacted on the nutritional status of patients. ~~is study did not investigate if the surgery was elective or for more acute diagnoses which may have impacted on nutritional status.~~ Multiple data collectors may have resulted in variations in data collection despite written instructions provided. A criterion for ineligibility was 'a condition that impacts on growth' however it can be argued that diagnose~~i~~s with chronic health problem such as cystic fibrosis or cardiac disease do impact on growth. These conditions where included in the study population as growth failure can be the result of poor nutrition.

This study found that the prevalence of malnutrition and ~~nutrition risk~~nutritional risk of Australian paediatric inpatients is much higher when compared to the healthy population. In contrast, the number of overweight and obese patients is less. The significant findings of this research should direct policy and planning of nutrition related healthcare by providing evidence for the implementation of national paediatric nutrition screening and incorporation of nutrition into mandatory hospital accreditation standards to achieve improved clinical outcomes for our paediatric inpatients.

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## Statement of Authorship

MW led the study design, coordinated the study nationally, participated in data collection, analysis and drafted the manuscript.

ND assisted in study design and coordination of ethics approvals nationally, participated in data collection and analysis.

RR performed the statistical analyses and helped draft the manuscript.

SK collated data from each study site and assisted in data analysis.

KB, CG, HK, LQ, AS, JW, DWS contributed to study design, ensured ethics approval and lead the study at their specific site and contributed to the manuscript.

RL conceived of the study, and participated in its design and coordination and helped to draft the manuscript.

All authors read and approved the final manuscript.

The authors have no conflict of interest and funding sources to declare.

References

1. Cunningham-Rundles S, McNeeley DF, Moon A. Mechanisms of nutrient modulation of the immune response. *J Allergy Clin Immunol* 2005; 115(6): 1119-1128.
2. Pawellek J, Dokoupil K, Koletzko B. Prevalence of malnutrition in paediatric hospital patients. *Clin Nutr* 2008; 27: 72-6.
3. Corbett SS, Drewett RF. To what extent is failure to thrive in infancy associated with poorer cognitive development? A review and meta-analysis. *J Child Psychol Psychiatry* 2004; 45(3): 641-654.
4. White M, Murphy A, Hallahan A, Ware R, Fraser C, Davies PSW. Survival in overweight and underweight children undergoing bone marrow transplantation. *Eur J Clin Nutr* 2012; 66: 1120-1123.
5. Aurangzeb B, Whitten KE, Harrison B, Mitchell M, Kepreotes H, Sidler M, Lemberg DA, Day AS. Prevalence of malnutrition and risk of under-nutrition in hospitalised children. *Clin Nutr* 2012; 31: 35-40.
6. O'Connor J, Youde LS, Allen JR, Baur LA. Obesity and under-nutrition in a tertiary paediatric hospital. *J Paediatric Child Health* 2004; 40: 299-304.

7. Hendricks KM Duggan C, Gallagher L, Carlin AC, Richardson DS, Collier SB, Simpson W, Lo C. Malnutrition in hospitalized pediatric patients: Current prevalence. *Arch Pediatr Adolesc Med* 1995; 149: 1118-22.
8. Sermet-Gaudelus I, Poisson-Saloman A, Colomb V, et al. Simple paediatric nutritional risk score to identify children at risk of malnutrition. *Am J Clin Nutr* 2000; 72: 64-70.
9. Moy RD, Smallman S, Booth IW. Malnutrition in a UK children's hospital. *J Hum Nutr Dietetics* 1990; 3: 93-100.
10. Joosten KF, Zwart H, Hop WC, Hulst JM. National malnutrition screening days in hospitalized children in the Netherlands. *Arch Dis Child* 2010; 5: 141-5.
11. Kelleher DK, Laussen P, Teixeira-Pinto A, Duggan C. Growth and correlates of nutritional statues among infants with hypoplastic left heart syndrome (HLHS) after stage 1 Norwood procedure. *Nutrition* 2006; 22(3): 237-244.
12. McCarthy H, Dixon M, Crabtree I, Eaton Evans M, McMulty H. The development and evaluation of the Screening Tool for Assessment of Malnutrition in Paediatrics (STAMP) for use by healthcare staff. *Journal of Human Nutrition and Dietetics* 2012; 25: 311-318.
13. Hulst JM, Zwart H, Hop WC, Joosten KF. Dutch national survey to test the STRONG(kids) nutritional risk screening tool in hospitalized children. *Clin Nutr* 2010; 29: 106-11.
14. Sermet-Gaudelus I, Poisson-Saloman A, Colomb V, et al. Simple paediatric nutritional risk score to identify children at risk of malnutrition. *Am J Clin Nutr* 2000; 72: 64-70.

15. Gerasimidis K, Keane O, Macleod I, Flynn D M, Wright CM. A four stage evaluation of the paediatric yorkhill malnutrition score in a tertiary paediatric hospital and a district general hospital. *Br J Nutr* 2010; 104(5): 751-6.
16. Wisken AE, Owens DR, Cornelius VR, Wootton SA, Beattie RM. Paediatric ~~nutrition risk~~nutritional risk scores in clinical practice: children with inflammatory bowel disease. *J Hum Nutr Diet* 2012; 25(4): 319-22.
17. Wong S, Graham A, Hirani SP, Grimble G, Forbes A. Validation of the Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP) in patients with spinal cord injuries (SCIs). *Spinal Cord* 2013; 51(5): 424-9.
18. World Health Organization. *Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. In: WHO technical report series 854.* Geneva: World Health Organization; 1995.
19. Chumlea W, Guo S, Steinbaugh, M. Prediction of stature from knee height for black and white adults and children with application to mobility-impaired or handicapped persons. *J Am Diet Assoc.* 1994; 94(12): 1385 - 1390.
20. Cole T J, Bellizi M C, Flegal K M, Dietz W H. Establishing a standard definition for child overweight and obesity worldwide: international survey. *Br Med J* 2000; 320: 1240-3.
21. Hartman C, Shamir R, Hecht C, Koletzko B. Malnutrition screening tools for hospitalized children. *Clin Nutr* 2012. published online May 2012. *www.co-clinicalnutrition.com*; 15(3);303-309.

22. Mehta N M, Corkins M R, Lyman B, Malone A, Goday P S, Carney L N, Monczka J L, Plogsted S W, Schewenk W F and the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N) Board of Directors. Defining Pediatric Malnutrition: A Paradigm Shift Toward Etiology-Related Definitions. JPEN 2013: published online March 25. DOI:10.1177/0148607113479972

23. Commonwealth Department of Health and Aged Care. Australian Refined Diagnosis Related Groups, version 4.1, Definitions Manual (Volumes 1-3). Canberra, Commonwealth Department of Health and Aged Care, 1998.

24. Olds T S, Tomkinson G R, Ferrar K E, Maher C A. Trends and prevalence of childhood overweight and obesity in Australia between 1985 and 2008. *Int J Obesity* 2010; 34: 57-66.

25. Cunningham J, Mackerras D. Overweight and obesity, Indigenous Australians. Australian Bureau of Statistics 1994. Occasional paper: 4702.0.

26. Spurrier N J, Volkmer R E, Abdallah C A, Chong A. South Australian four-year-old Aboriginal children: residence and socioeconomic status influence weight. *Aust NZ J Public Health* 2012; 36: 285-290.

27. Forchielli M L, McColl R, Walker W A, Lo C. Children with congenital heart disease: a nutrition challenge. *Nutr Rev* 1994; 52(10): 348-353.

28. Yen E H, Quinton H, Borowitz D. Better nutritional status in early childhood is associated with improved clinical outcomes and survival in patients with cyctic fibrosis. *J Pediatri* 2013; 162(3): 530-535.

29. Eskedal L T, Hagemo P S, Seem E, Eskild A, Cvancarova M, Seiler S, Thaulow E. Impaired weight gain predicts risk of late death after surgery for congenital heart defects. *Arch Dis Child* 2008; 93(6): 495-501.

Table 1: Ineligibility criteria for collection of anthropometric~~nutritional status~~ and nutritional risk data among the paediatric inpatient population across 16 hospitals (N = 1175)

| **Ineligibility Criteria** | **N (%)** |
|---|---|
| Non ambulatory; knee height or supine length unable to be measured | 35 (3.0) |
| Critically ill; unable to be weighed | 63 (5.4) |
| Weight unable to be accurately measured | 73 (6.2) |
| Admitted for palliative care | 4 (0.3) |
| Patient/carer decline measurement | 71 (6.0) |
| Born premature; not yet term age | 35 (3.0) |
| Admitted as day patient | 4 (0.3) |
| Condition known to effect growth | 7 (0.6) |
| Other | 45 (3.8) |

Table 2: Demographic characteristics of paediatric inpatients eligible for collection of anthropometric (N=832) and nutritional (N=570) risk data across 16 hospitals. ~~(N=832)~~

| **Demographic Characteristics** | **N (%) or M (min – max)** |
|---|---|
| Hospital | |
| *Tertiary* | 670 (80.5) |
| *Regional* | 162 (19.5) |
| Gender (male) | 384 (46.2) |
| Age (months) *M(min – max)* | 64 (0-226) |
| ATSI status | |
| *Aboriginal and/or Torres Strait Islander* | 107 (12.8) |
| *Not Aboriginal and/or Torres Strait Islander* | 684 (82.2) |
| Primary Diagnosis | |
| *Oncology* | 105 (12.6) |
| *Cystic Fibrosis* | 35 (4.2) |
| *Gastroenterology* | 81 (9.7) |
| *Surgical* | 33 (4.0) |
| *Cardiac* | 42 (5.0) |
| *Other* | 410 (49.2) |
| Reason for admission | |
| *Surgical* | 141 (16.9) |
| *Gastroenterology* | 21 (2.5) |
| *Respiratory* | 121 (14.5) |
| *Infection* | 110 (13.2) |
| *Other* | 409 (49.0) |

Table 3: Anthropometrics and z scores of paediatric inpatients.

| Anthropometry | Median (range) |
|---|---|
| Weight (kg) | 18.4 (1.85, 136.8) |
| Height/Length (cm) | 110 (31, 188.7) |
| BMI kg/$m^2$ | 16.23 (7.9, 42.14) |
| Weight for age z score | -0.2 (-6.03, 4.77) |
| Height for age z score | -0.13 (-6.77, 4.54) |
| BMI z score | -0.27 (-5.72, 7.23) |

Table 43: Prevalence and level of malnutritourishion (BMI z score)ed, wasting (weight for age z score)ed and , stunting (height for age z score)ed, children among paediatric inpatients across 16 hospitals (N = 832).

| Anthropometry **N (%)** | ≤ -1 | ≤ -2 | ≤ -3 |
|---|---|---|---|
| BMI z score | 256 (30.8) | 122 (15) | 45 (5.5) |
| Weight for age z sore | 246 (29.6) | 114 (13.8) | 53 (6.4) |
| Height for age z score | 226 (27.2) | 97 (11.9) | 49 (6.0) |

Table 5: Associations between patient demographics and z scores among 832 paediatric inpatients across 16 hospitals[1]

| Demographic characteristics | BMI z core | | Weight for age z score | | Height for age z score | |
|---|---|---|---|---|---|---|
| | B (SE) | p-value | B (SE) | p-value | B (SE) | p-value |
| Gender | -0.024 (0.128) | 0.55 | -0.012 (0.120) | 0.75 | 0.007 (0.128) | 0.87 |
| Age | 0.128 (0.246) | 0.003* | 0.191 (0.001) | <0.001* | 0.136 (0.001) | 0.002* |
| ATSI status | 0.014 (0.208) | 0.74 | -0.049 (0.195) | 0.23 | -0.129 (0.207) | 0.002* |
| Tertiary hospital | 0.183 (0.199) | <0.001* | 0.164 (0.186) | <0.001* | 0.081 (0.198) | 0.05* |
| Diagnosis | | | | | | |
| *Oncology* | 0.027 (0.184) | 0.51 | 0.022 (0.172) | 0.58 | -0.024 (0.183) | 0.56 |
| *Cystic fibrosis* | -0.089 (0.332) | 0.04* | -0.081 (0.312) | 0.05* | -0.038 (0.331) | 0.38 |
| *Gastroenterology* | -0.031 (0.227) | 0.48 | -0.056 (0.214) | 0.19 | -0.048 (0.227) | 0.27 |
| *Surgery* | 0.102 (0.341) | 0.01* | 0.096 (0.304) | 0.01* | 0.029 (0.341) | 0.46 |
| *Cardiac* | -0.112 (0.285) | 0.007* | -0.136 (0.265) | 0.001* | -0.107 (0.284) | 0.01* |
| Admission: | | | | | | |
| *Surgery* | -0.123 (0.244) | 0.03* | 0.033 (0.227) | 0.54 | 0.168 (0.243) | 0.003* |
| *Gastroenterology* | -0.045 (0.434) | 0.33 | -0.062 (0.409) | 0.16 | -0.002 (0.441) | 0.96 |
| *Infection* | -0.072 (0.256) | 0.16 | 0.046 (0.240) | 0.35 | 0.158 (0.256) | 0.002* |
| *Other* | -0.183 (0.202) | 0.003* | -0.088 (0.189) | 0.15 | 0.070 (0.202) | 0.26 |

[1]Adjusted for primary diagnosis, reason for admission, gender, age and ATSI status

Table 6:5 Associations (Odds ratio (95% CI)) between patient demographics and malnutrition, wasting, stunting, nutritionalal risk and overweight/-obesity among paediatric inpatients (N = 832)

| | Malnutrition (BMI z score ≤-2) | Wasting (Weight z score ≤-2) | Stunting (Height ≤-2 z score) | Nutritional risk (PYMS ≥ 2) | Overweight/obese (BMI z score ≥ 1.036) |
|---|---|---|---|---|---|
| **Gender (Female)** | 0.92 (0.60 – 1.40) | 0.93 (0.59 – 1.47) | 0.67 (0.42 – 1.10) | 1.00 (0.69 – 1.44) | 0.93 (0.03 – 1.36) |
| **ATSI status** | 1.32 (0.74 – 2.35) | 1.68 (0.92 – 3.05) | 2.94 (1.60 – 5.43)* | 0.91 (0.50 – 1.68) | 1.14 (0.63 – 2.07) |
| **Regional hospital** | 2.23 (1.29 – 3.84)* | 2.19 (1.23 – 3.93)* | 1.16 (0.61 – 2.21) | 1.20 (0.70 – 2.06) | 0.37 (0.20 – 0.70)* |
| **Diagnosis** | | | | | |
| *Oncology* | 1.10 (0.57 – 2.13) | 0.56 (0.24 – 1.32) | 0.56 (0.22 – 1.42) | 2.14 (1.29 – 3.54)* | 1.08 (0.62 – 1.89) |
| *Cystic fibrosis* | 1.48 (0.40 – 5.54) | 0.50 (0.06 – 4.12) | 0.53 (0.06 – 4.36) | 0.35 (0.13 – 0.94)* | 0.09 (0.01 – 0.71)* |
| *Gastroenterology* | 0.88 (0.36 – 2.14) | 1.27 (0.54 – 2.97) | 1.25 (0.49 – 3.23) | 1.95 (1.02 – 3.73)* | 0.45 (0.19 – 1.10) |
| *Surgery* | NA | 0.26 (0.03 – 2.06) | 0.71 (0.15 – 3.32) | 0.25 (0.05 – 1.12) | 3.28 (1.34 – 8.03)* |
| *Cardiac* | 4.03 (1.85 – 8.73)* | 5.05 (2.23 – 11.43)* | 2.28 (0.88 – 5.89) | 1.10 (0.33 – 3.70) | 0.83 (0.32 – 2.17) |
| **Admission** | | | | | |
| *Surgery* | 0.86 (0.47 – 1.58) | 0.34 (0.16 – 0.71)* | 0.26 (0.11 – 0.63)* | 0.80 (0.48 – 1.36) | 1.30 (0.77 – 2.21) |
| *Gastroenterology* | 0.30 (0.03 – 2.32) | 0.98 (0.27 – 3.59) | 0.93 (0.21 – 4.04) | 1.53 (0.49 – 4.81) | 0.98 (0.29 – 4.81) |
| *Respiratory* | 0.50 (0.25 – 0.99)* | 0.55 (0.29 – 1.07) | 0.99 (0.54 – 1.85) | 1.70 (0.87 – 3.32) | 1.60 (0.88 – 2.93) |
| *Infection* | 0.76 (0.40 – 1.43) | 0.38 (0.18 – 0.74) | 0.29 (0.62 – 2.21) | 1.41 (0.82 – 2.06) | 1.47 (0.84 – 2.58) |

CI, confidence interval. NA, not available.
* Significant $p < 0.05$