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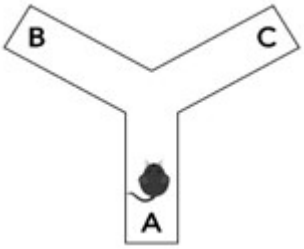

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Original Research Report

THE USE OF STRONGkids, TOTAL LYMPHOCYTE COUNT, AND SERUM ALBUMIN TO IDENTIFY THE RISK OF HOSPITAL MALNUTRITION IN CHILDREN

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ABSTRACT

Hospital malnutrition occurs in hospitalized patients who do not consume enough food while their nutritional requirements increase. It occurs particularly in children who have undergone gastrointestinal surgery. Despite the lack of a universal instrument for detecting hospital malnutrition, various parameters can be considered to assist in its identification. STRONGkids has demonstrated its efficiency in detecting malnutrition risk in children. Total lymphocyte count (TLC) and serum albumin are biochemical markers that are related to infection and protein leakage, which can worsen hospital malnutrition. The research objective was to analyze the correlation between STRONGkids and biochemical markers (TLC, serum albumin) to identify hospital malnutrition in children who underwent gastrointestinal surgery. This was a retrospective cross-sectional observational study utilizing medical records. The statistical analysis was conducted using SPSS 21. This study included 37 subjects, with a 24.32% hospital malnutrition incidence rate. The subjects were divided into two groups: hospital malnutrition (n=9) and non-hospital malnutrition (n=28). The STRONGkids of both groups at admission demonstrated a significant difference, while the albumin and TLC did not. The significantly different STRONGkids scores of both groups at admission correlated negatively with the length of hospital stay (LOS), body weight reduction, TLC, and albumin. Those parameters also did not correlate with hospital malnutrition. However, hospital malnutrition increased the risk of low albumin and TLC at discharge by 2.951 and 5.549 times, respectively. In conlusion, TLC and serum albumin cannot be used as independent markers for hospital malnutrition, but STRONGkids can be used in conjunction with TLC and serum albumin to identify hospital malnutrition risk.

Keywords: Total lymphocyte count; serum albumin; STRONGkids; hospital malnutrition; children

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Highlights:

1. Medium- and high-risk STRONGkids scores are related with low total lymphocyte count and serum albumin, which are related to hospital malnutrition, albeit indirectly.
2. The use of STRONGkids with total lymphocyte count and serum albumin can detect the risk of hospital malnutrition in children.

INTRODUCTION

Hospital malnutrition refers to malnutrition that occurs during hospital treatment (Juliaty 2016). Hospital malnutrition is a common and undertreated condition in oncology patients, leading to longer hospital stays and higher healthcare costs (Planas et al. 2016). Hospital malnutrition prevention and treatment represents a tremendous opportunity to improve overall patient care quality, clinical outcomes, and cost-effectiveness (Tappenden et al. 2013). The hospital malnutrition prevalence in children ranges from 6.1% to 51.6%, depending on the population studied and the diagnostic criteria used. The data are supported by the proportion of hospitalized children with malnutrition at several

Indonesian hospitals, including Dr. Sardjito Central General Hospital, Yogyakarta (27%), Sanglah Central General Hospital, Denpasar (31.5%), Saiful Anwar General Hospital, Malang (24.3%), and Mohammad Hoesin Central General Hospital, Palembang, Indonesia (37%) (Maryani et al. 2017). Patients undergoing abdominal surgery are typically susceptible to malnutrition. This is due to dietary restriction, surgical stress, long periods of starvation before and after surgery, and an increase in metabolic rate after surgery (Permsombut et al. 2013). A study utilizing anthropometric measurements from the World Health Organization (WHO) for the pre-operative period found that the prevalence of malnutrition was 46.2% among children admitted for elective general surgery in Nigeria (Adigun & Ogundoyin 2020).

Malnutrition is significant in children who have had gastrointestinal surgery because it increases complications from the primary disease, resulting in local infection, systemic infection, additional surgery intervention, and an extended length of hospital stay (LOS) (Koofy et al. 2021). Malnutrition in children is even significantly related to the incidence of pneumonia and stunting (Sekiyama et al. 2015, Wicaksono 2016). There are several interventions to prevent the condition, but it is unclear how well they are adopted by both malnourished and well-nourished children and their mothers, and to what extent socioeconomic factors have impacts (Tette et al. 2015). It is prevalent in pediatric patients with diarrhea and acyanotic congenital heart defect (Fedora et al. 2019, Jordan et al. 2020). Therefore, identifying malnourished patients, particularly in children, through hospital malnutrition risk assessment is important.

In daily practice, many nutritional screening tools (NST) are used to identify the risk of hospital malnutrition in children, but none is universally accepted (Lee 2018). Screening Tool for Risk on Nutritional Status and Growth (STRONGkids) is one of the most frequently used NST (Hulst et al. 2010). Rocha & Fortes (2015) found that in addition to NST, total lymphocyte count (TLC) and serum albumin should be considered as supporting biochemical parameters for identifying malnutrition. The European Society for Parenteral and Enteral Nutrition (ESPEN) and American Society for Parenteral and Enteral Nutrition (ASPEN) have recommended guidelines for nutritional risk screening to identify hospitalized patients at risk of malnutrition (Kondrup 2003, Thibault et al. 2021). With the provided information, fewer patients are expected to have to deal with the complications of nutritional imbalance despite also suffering from their underlying disease.

MATERIALS AND METHODS

This retrospective observational cross-sectional study was conducted from October 2021 to January 2022 at Dr. Soetomo General Academic Hospital, Surabaya, Indonesia. All subjects in this study were children aged 3 to 24 months who underwent gastrointestinal surgery at the Chlid Health Department of Dr. Soetomo General Academic Hospital between January 2016 and January 2021. All data were extracted from the medical records of the subjects. Subjects with a tumor, syndrome anomaly, dysmorphic facial features, down syndrome, or incomplete medical record were excluded from the study.

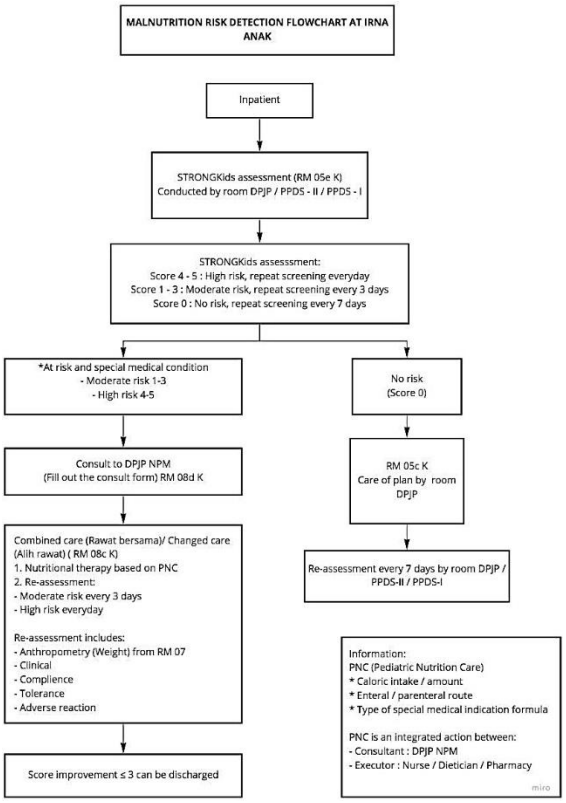
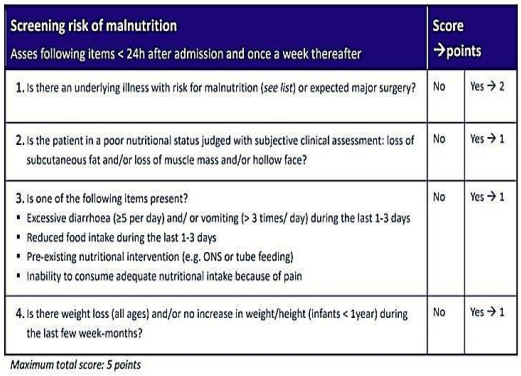


Figure 1. Flowchart of the malnutrition risk detection at Dr. Soetomo General Academic Hospital (Wahyuhadi 2018).

The data obtained from the study consisted of age, gender, serum albumin, total lymphocyte count, and STRONGkids score. As suggested by Maryani et al. (2017), this study defined hospital malnutrition as malnutrition that occurs during hospitalization, as indicated by a decrease in weight of >2% within 7 days, 5% within 8 to 30 days, or 10% within >30 days. The biochemical marker data from laboratory assessment were obtained from two distinct time periods, i.e., one from at least three days before the surgery and the other from at least three days after

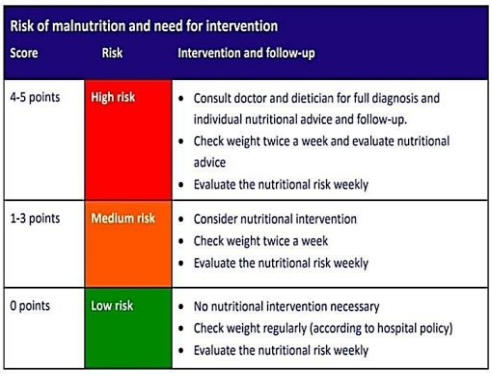
the surgery. All assessment results were collected by laboratory personnel. Serum albumin concentrations and total lymphocyte counts were the variables under investigation in this study. The cutoff point for normal serum albumin concentration in this study was consistent with previous research, whereas ≤3.00 g/dL was considered hypoalbuminemia.



Screening risk of malnutrition Asses following items < 24h after admission and once a week thereafter	Score →points	
1. Is there an underlying illness with risk for malnutrition (*see list*) or expected major surgery?	No	Yes → 2
2. Is the patient in a poor nutritional status judged with subjective clinical assessment: loss of subcutaneous fat and/or loss of muscle mass and/or hollow face?	No	Yes → 1
3. Is one of the following items present? ▪ Excessive diarrhoea (≥5 per day) and/ or vomiting (> 3 times/ day) during the last 1-3 days ▪ Reduced food intake during the last 1-3 days ▪ Pre-existing nutritional intervention (e.g. ONS or tube feeding) ▪ Inability to consume adequate nutritional intake because of pain	No	Yes → 1
4. Is there weight loss (all ages) and/or no increase in weight/height (infants < 1year) during the last few week-months?	No	Yes → 1

Maximum total score: 5 points

Figure 2. Factors and scores in the assessment of malnutritionusing STRONGkids (Rad 2019).



Risk of malnutrition and need for intervention Score	Risk	Intervention and follow-up
4-5 points	High risk	• Consult doctor and dietician for full diagnosis and individual nutritional advice and follow-up. • Check weight twice a week and evaluate nutritional advice • Evaluate the nutritional risk weekly
1-3 points	Medium risk	• Consider nutritional intervention • Check weight twice a week • Evaluate the nutritional risk weekly
0 points	Low risk	• No nutritional intervention necessary • Check weight regularly (according to hospital policy) • Evaluate the nutritional risk weekly

Figure 3. Interpretation of malnutrition risk according to the STRONGkids scores (Rad 2019).

The total lymphocyte count was calculated by combining the lymphocyte percentage and the leucogram value. The cutoff point for normal TLC was <3000 cells/m^3, according to a study by Tosato et al. (2015). A study on malnutrition in pediatric HIV patients also affirmed to use 3000 cells/m^3 as the cutoffpoint for TLC (Widjaja et al. 2016). The data were collected for analysis using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp. Armonk, N.Y., USA). The results were then assessed using the Spearman correlation test along with the Kolmogorov-Smirnov normality test. The Pearson correlation test confirmed the degree of association between the variables for the diagnosis without categories. In order to compare the various parameters, analyses were carried out using binary logistic regression, Chi-square, Fisher's exact, independent t-test, Mann-Whitney test, Spearman's rho, and Pearson'scorrelation, with $p<0.05$ indicated a significance.

RESULTS

A total of 37 samples retrieved from the medical records were eligible to fulfil all of the inclusion criteria. Nine subjects (24.3%) were found to have hospital malnutrition. Table 1 shows the characteristics of the hospitalized patients with malnutrition.

Table 1. General characteristics of the hospitalized subjects.

	HMN (n=9)	Non-HMN (n=28)	*p*
	Mean±SD	Mean±SD	
Age, months	8.78 ±3.31	11.00 ±8.17	0.986[1]
Sex, n (%)			
-Male	7 (77.78)	15 (53.57)	0.262[2]
-Female	2 (22.22)	13 (48.43)	
Diagnosis, n (%)			
-Ileal obstruction	3 (33.33)	8 (28.57)	
-Duodenal obstruction	2 (22.22)	6 (21.42)	
-Hirschsprung's disease	1 (11.11)	7 (25)	0.898[4]
-Intussusception	2 (22.22)	5 (17.85)	
-Hypertrophic pyloric stenosis	1 (11.11)	1 (3.57)	
-Volvulus	0 (0)	1 (3.57)	
LOS, day	24.33 ±27.23	28.07 ±22.92	0.687[3]
Weight			
-Admission	5.78 ±1.74	5.96 ±2.06	0.820[3]
-Discharge	5.39 ±1.72	6.28 ±2.07	0.254[3]
Length/height			
-Admission	61.50 ±7.19	63.96 ±8.60	0.443[3]
-Discharge	61.72 ±7.29	64.54 ±8.38	0.373[3]
STRONGkids at admission, n (%)	3.22 ±0.66	2.82 ±0.67	0.127[3]
-Moderate risk	6 (66.67)	0.3732	0.373[2]
-High risk	3 (33.33)	5 (17.86)	
STRONGkids at discharge, n (%)	3.56 ±0.88	2.82 ±0.66	0.012[3]
-Moderate risk	4 (44.44)	0.0412	0.041[2]
-High risk	5 (55.56)	5 (17.86)	
Albumin levels, g/dL			
-Admission	3.57 ±0.54	3.45 ±0.55	0.579[3]
-Dsciharge	3.05 ±0.45	3.21 ±0.46	0.356[3]
-Change (Δ)	-0.52 ±0.57	-0.24 ±0.53	0.631[3]
TLC, cells/mm3			
-Admission	3,996.67 ±2,668.03	3,707.14 ±1,784.06	0.711[3]
-Discharge	3,006.66 ±2,173.74	3,077.14 ±1,293.78	0.906[3]
-Change (Δ)	-990.00 ±2,528.15	-630.00 ±1,727.02	0.631[3]

[1]Independent sample T-test, [2]Fischer exact test, [3]Mann-Whitney U test, [4]Pearson Chi-square test

The subjects were divided into two groups on the basis of body weight loss since admission: the hospital malnutrition group (abbreviated as HMN, n=9) and the non-hospital malnutrition group (abbreviated as non-HMN, n=28). Other than the STRONGkids scores and other parameters at admission, there were no noticeable differences between the two groups. The hospital malnutrition group had a higher risk (55.56%) compared to the non-hospital malnutrition group, as indicated by the STRONGkids scores of 3.56±0.88 and 2.82±0.66, respectively (p=0.012).

Table 2. Correlation of the STRONGkids and hospital malnutrition with the biochemical markers.

Variable	STRONGkids score at admission	Body weight change → HMN ruler
Length of hospital stay (LOS)	r=0.413, p=0.011[2]	r=0.283, p=0.089[1]
Body weight at discharge	r=-0.434, p=0.007[2]	r=0.013, p=0.941[1]
Albumin at discharge	r=-0.521, p=0.001[2]	r=0.030, p=0.862[1]
Delta (Δ) Albumin	r=0.193, p=0.251[2]	r=-0.033, p=0.647[1]
TLC at admission	r=-0.475, p=0.003[2]	r=0.028, p=0.868[1]
TLC at discharge	r=-0.665, p=0.000[2]	r=-0.097, p=0.862[1]
Delta (Δ) TLC	r=0.096, p=0.572[2]	r=-0.112, p=0.510[1]

[1]Pearson's correlation, [2]Spearman's rho

Table 2 shows the correlation of STRONGkids scores and hospital malnutrition with TLC and serum albumin. The STRONGkids scores were negatively correlated with body weight at discharge (r=-0.434, p=0.007), serum albumin at discharge (r=-0.521, p=0.001), and TLC at admission (r=-0.475, p=0.003) and at discharge (r=-0.665, p=0.000). There was no other significant difference between the variables (p>0.05). The hospital malnutrition did not show any correlation with the other parameters.

Table 3. Bivariate analysis of the biochemical markers associated with the STRONGkids score.

	Hypoalbuminemia at discharge	Low TLC at discharge
B	1.082	1.714
SE	0.862	1.723
Exp (B)	2.951	5.549
p[1]	0.209	0.320
95% CI		
Lower	0.545	0.190
Upper	15.980	162.360

As shown in Table 3, hospital malnutrition increased the TLC by 5.549 times (95% CI [0.190-162.360]) and the risk of hypoalbuminemia by 2.951 times (95% CI [0.545-15.980]) at discharge.

Table 4. Bivariate analysis of the biochemical markers associated with hospital malnutrition.

	Hypoalbuminemia at discharge	Low TLC at discharge
B	1.872	2.104
SE	0.988	1.760
Exp (B)	6.500	8.196
p[1]	0.058	0.232
95% CI		
Lower	0.937	0.260
Upper	45.103	258.206

Table 4 demonstrates that a high-risk STRONGkids score also increased the risk of hypoalbuminemia at discharge by 6.5 times (95% CI [0.937-45.103], p=0.058) and of low TLC by 8.196 times (95% CI [0.260-258.206], p=0.23).

DISCUSSION

In the absence of appropriate perioperative nutritional support, the incidence of malnutrition in hospitals is associated with longer hospital stays, complications, and an increased risk of mortality (Mosquera et al. 2016). In this study, there was a correlation between hospital malnutrition and STRONGkids score, but not with the other factors examined. However, with the aid of a nutritional risk screening tool and biomarker parameters, the risk of hospital malnutrition could be identified earlier, thereby preventing patients from developing additional disease-related complications (Mehta & Compher 2009, Rocha & Fortes 2015, Thibault et al. 2021).

STRONGkids is a valid questionnaire that is used as a screening tool for malnutrition in various parts of the world (Carter et al. 2020). STRONGkids was used as the nutritional risk screening tool in this study not only due to the hospital's guidelines, but also because a NewZealand study demonstrated that it was practical and easier to use than other tools for identifying children at risk of malnutrition (Moeeni et al. 2014). STRONGkids is a useful tool for identifying the risk of severe malnutrition in hospitalized patients (Malekiantaghi et al. 2022). Hulst et al. (2020), conducted a multi-center study in hospitals and STRONGkids. They discovered a link between having a "high risk" STRONGkids score and having a negative SD-score in weight-for-height. Another systematicreview study demonstrat-

ed that STRONGkids was a valid tool for detecting hospital malnutrition risk (dos Santos et al. 2019). STRONGkids can detect malnutrition earlier than anthropometric measures and attend to patients' nutrition changes due to hospitalization, so they can be useful tools for hospitalized children.

The STRONGkids scores were analyzed to determine whether there was any significant difference between the hospital malnutrition and non-hospital malnutrition groups at admission and discharge. The STRONGkids scores of the hospital malnutrition and non-hospital malnutrition groups differed significantly, indicating that STRONGkids and hospital malnutrition were correlated. This is explained by the STRONGkids employed to identify hospital malnutrition in the patients, with the assessed factors including subjective clinical evaluation, high-risk diseases, reduced nutritional intake, weight reduction or poor weight gain (Figure 2). Referring to Figure 3, the STRONGkids scores are totaled based on the aforementioned factors and then categorized as high-, medium-, or low-risk. If a patient's score is in the moderate- or high-risk categories, hospital malnutrition is most likely present.

The STRONGkids scores at discharge between the hospital malnutrition and non-hospital malnutrition groups demonstrated a significant difference in this study ($p=0.012$). The scores serve to describe the current nutritional state, the frequency of weight loss, and a decrease in food ingestion, all of which contribute to the tendency of weight loss (Tommy et al. 2022). To track any weight changes that could have an impact on the patient's condition, the scores were evaluated twice, once before surgery and once after, in accordance with the hospital policy (Figure 1). Despite being correlated with the STRONGkids scores at discharge, the scores at admission did not significantly differ between the groups, which we assume was due to the amount of data available from medical records.

There have been research examining the relationship between the length of hospital stay and STRONGkids score since hospital malnutrition is frequently associated with hospital stays. A univariate analysis demonstrated that children with low-risk scores had noticeably shorter length of stay compared to those with medium- or high-risk scores, with the median of two versus three days between the low risk and medium- or high-risk scores, respectively ($p<0.001$). A multivariate study also demonstrated that the nutritional risk category continued to be important in demonstrating length of hospital stay discrepancies between low-risk and medium- or high-risk even if other factors linked to prolonged hospitalization were considered (Hulst et al. 2010).

The STRONGkids and biochemical parameters

This study investigated whether the correlation of STRONGkids with serum albumin and TLC had an impact on the likelihood of hospital malnutrition. It was discovered that serum albumin levels measured at discharge was related to the STRONGkids scores, but not to hospital malnutrition. In other words, the lower the serum albumin level, the higher the STRONGkids score.

Even though there has not been any research on the specific connection between serum albumin and hospital malnutrition, the relationship between low serum albumin levels and the STRONGkids score can be explained by acute stress in the body that led to the decrease of serum albumin level. Acute stress-induced inflammation can result in capillary leaks that may cause the extravasation of serum proteins into the interstitial space, reduced oncotic pressure that initiates extravasation within the inflammatory state, intravascular volume depletion, and loss of serum proteins (Loftus et al. 2019). This would imply a link between serum albumin and hospital malnutrition, albeit indirectly, through the recognized evidence of how STRONGkids can be deemed a helpful and valid measurement of nutritional risk (dos Santos et al. 2019). Another study focusing on adolescents and children with liver disease used the STRONGkids in the nutritional risk assessment to examine the relationship between serum albumin and dietary intake. They discovered that more patients in the high-risk group had lower serum albumin and prealbumin than those in the moderate-risk group ($p<0.001$) (Song et al.2017).

This study demonstrated a correlation between the STRONGkids scores and TLC at admission and discharge, which implying that the greater the STRONGkids score, the higher the malnutrition risk. This occurence was explained by how low TLC could degrade lymphocyte quality, making children more susceptible to recurring infections and inflammation, which changed the metabolism process (including the energy, protein, and mineral metabolism) within the infected individual. Following this condition, energy requirements would increase to aid in the elimination of the infection process, as well as the depletion of glycogen and fat reserves. Malnutrition will occur if immediate nutritional supplementation is not provided (Ibrahim et al. 2017). In light of this, a recent study from Sanglah General Hospital, Bali, Indonesia, revealed a significant correlation between TLC and the occurrenceof hospital malnutrition ($p=0.002$). Using a cut-off value of 4,000 cells/mm^3, children between the ages of 6 and 12 months were found to have a 61.8% hospital malnutrition incidence rate and a 32.3% rate of normal TLC, as well as a 3.9 times

higher risk of hospital malnutrition for those with low TLC, with a 95% confidence interval between 1.5 and 7.1. These data suggested that low TLC levels can be used to predict the development of hospital malnutrition (Ekaputri et al. 2021).

Other nutritional screening tools

STRONGKids exhibited the highest specificity (100%) to detect acute malnutrition in hospitalized children, with a positive predictive value of 36% when compared to the Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP), Pediatric Yorkhill Malnutrition Score (PYM), and Finnish national growth charts (Tuokkola et al. 2019). However, because there has not been a study that estimates the risk of low albumin and low TLC in child patients, the study examined the sensitivity of the STRONGkids based on anthropometric measurements rather than biochemical markers of malnutrition, e.g., albumin and TLC.

A study in Yogyakarta,Indonesia, using the Simple Nutrition Screening Tool (SNST), Nutritional Risk Screening (NRS) 2002,Malnutrition Screening Tool (MST), Malnutrition Universal Screening Tool (MUST), and Short Nutritional Assessment Questionnaire (SNAQ) revealed that medium- and high-risk malnourished patients had low albumin levels that were 2.84-2.98 times higher in elderly (Susetyowati et al. 2018). Another study found that the elderly, particularly those with a lower level of education, frequently consume an insufficient amount of energy (Setiati et al. 2013). Robinson (2015) also discovered that older people with low serum albumin had a 3.27 hazard ratio for hospital readmission within 30 days. Mild hypoalbuminemia in colorectal cancer patients increased the risk of mortality by 1.74 times (Hu et al. 2019). Patients who underwent abdominal surgery and had a nutritional risk index (NRI) score below 97.5 were 1.8 times more likely to experience poor wound healing (Hussen et al. 2020). The likelihood of low TLC in COVID-19 patients was also 3.05 times higher when malnutrition was present (Zhang et al. 2022)

Strength and limitations

As there were few studies in Indonesia that discussed hospital malnutrition in children admitted to surgery and its risk screening, this study's strength was that it offered useful information about the incidence of hospital malnutrition and the STRONGkids' use among pediatric patients who were scheduled for surgery. It will also help future studies to investigate more about serum albumin and TLC and their correlation with the occurrence of hospital malnutrition.

One of the study's limitations was that the subjective assessments of the STRONGkids were performed by many clinicians, as the data were all gathered from medical records. It also did not allow this study to accurately monitor a wider range of the patients' condition. Another limitation of this study that might have resulted in insignificant findings between hospital malnutrition and other parameters was that the data being analyzed with an insufficient number of accessible medical records and time inconsistency while retrieving the biochemical markers. We suggest future studies to conduct prospective study and observe additional patient outcomes (i.e., secondary infections and presence of edema).

CONCLUSION

This study proved that total lymphocyte count and serum albumin cannot be utilized as independent markers of hospital malnutrition. However, with the use of a nutritional risk screening tool (i.e., STRONGkids), total lymphocyte count and serum albumin can both operate as additional markers to help identify the risk of hospital malnutrition to avert complications in children undergoing gastro-intestinal surgery.

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Conflict of interest

None.

Ethical consideration

An ethical approval was obtained from the Research Ethics Commission, Dr. Soetomo General Academic Hospital (No. 0653/LOE/301.4.2/X/2021 on 18/10/2021).

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Author contribution

HAR oversaw the conception or design of this study, as well as the data acquisition, analysis, and interpretation. NAW, RI, and AS critically examined and revised the manuscript for important intellectual content and approved the final version for publication.

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