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Original article

Acute malnutrition and postoperative outcomes in pediatric abdominal surgery

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SUMMARY

Background: Malnutrition is highly prevalent among surgical children in sub-Saharan Africa, but data on its association with postoperative outcomes are limited. This study presents the first dataset on malnutrition and postoperative outcomes in children undergoing major gastrointestinal (GI) surgery in Uganda. We retrospectively evaluated the association between preoperative malnutrition and postoperative outcomes in young children undergoing major GI surgery.
Methods: A retrospective cohort study of children aged 1–59 months who underwent major GI surgery at the Children's Surgical Hospital, Entebbe, between April 2021 and November 2024. Nutritional status was assessed at admission using WHO Z-scores and mid-upper arm circumference (MUAC) cut-offs, classifying children as stunted (height-for-age Z-score < -2) and/or wasted (weight-for-length/height Z-score < -2, or MUAC below the age-specific cut-off). Outcomes included postoperative complications (primary), complication severity, length of hospital stay, and pediatric intensive care unit admission. Multivariable regression models adjusted for demographic and clinical covariates.
Results: We included 274 children, 117 (42.7%) female, with a mean age of 24.5 ± 14.1 months. The most frequent diagnoses were anorectal malformations in 190 (69.3%) and Hirschsprung's disease in 64 (23.4%). At admission, 107 (39.0%) were stunted and 68 (24.8%) wasted. Overall, 95 (35.6%) experienced at least one postoperative complication, and 21 (7.7%) experienced two, resulting in a total of 116 complications. The most frequent were wound infections or dehiscence in 62 (53.4%) and urinary tract infection in 25 (21.6%). There were 6 fatalities (2.2%). After adjustment, wasting was independently associated with postoperative complications (OR 3.74; 95% CI 1.14–13.38; $p = 0.03$), while stunting showed no such association. Neither stunting nor wasting was associated with other outcomes.
Conclusions: Wasting is associated with higher odds of postoperative complications in pediatric abdominal surgery, although the confidence interval is wide. These findings underscore the need for prospective interventional studies to clarify causal relationships and determine whether targeted perioperative nutritional interventions can improve postoperative outcomes in pediatric surgical patients.

1. Introduction

Malnutrition is a major contributor to morbidity and mortality among children under five years worldwide, with the highest burden in sub-Saharan Africa [1]. In Uganda, the 2022 Demographic and Health Survey (DHS) reported 24.4% stunting, 3.2% wasting, and 9.7% underweight among children aged 0–59 months

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[2]. Recent evidence indicates that malnutrition disproportionately affects the most vulnerable populations, particularly those living in rural areas and regions with high food insecurity—such as Karamoja, Kigezi, and Tooro—where stunting prevalence exceeds the national average [3]. These disparities reflect the combined effects of structural poverty, low maternal education, climate vulnerability, limited access to healthcare, poor sanitation, suboptimal infant feeding practices, and a high burden of infectious diseases [4].

To address acute malnutrition, Uganda implements the Integrated Management of Acute Malnutrition strategy, combining facility-based care and community-based management using ready-to-use therapeutic foods (RUTF) and routine nutritional screening [5].

Nutritional status significantly affects surgical outcomes [6,7]. Surgically induced stress–related catabolism, characterized by systemic inflammation, protein breakdown, and nitrogen loss, creates a hypermetabolic state that increases the risk of poor wound healing, infection, gastrointestinal bacterial overgrowth, prolonged hospitalization, and mortality [8]. These effects are particularly detrimental in malnourished children, as surgical stress worsens nutritional deficits, impairs immunity and intestinal barrier function, and increases complications while hindering growth and neurodevelopment [9,10]. The American Society for Enhanced Recovery and the Perioperative Quality Initiative (ASER-POQI) consensus underscores that, within enhanced recovery pathways, nutritional screening and optimization are essential perioperative components [11]. Accordingly, malnutrition in pediatric patients has been consistently associated with higher rates of postoperative complications, delayed recovery, prolonged hospital and ICU stays, and increased mortality, highlighting the importance of understanding its specific impact across different surgical contexts [7,12].

This concern is particularly relevant for children undergoing gastrointestinal (GI) surgery, who may face an elevated risk of malnutrition, possibly related to feeding challenges, nutrient loss, or increased metabolic demands [13]. In Uganda, these risks may be amplified by systemic limitations, delays in accessing care, and caregiver-related barriers such as financial constraints and limited health literacy [14].

In the East African context, common GI surgical indications include congenital colorectal anomalies such as anorectal malformations (ARM) and Hirschsprung's disease (HD). ARM accounts for 57–67% of neonatal intestinal obstruction cases in regional referral centers, with delayed presentation frequent in Uganda [15,16]. HD, with a global incidence of approximately 1 in 5000 live births, also faces diagnostic delays in this setting [17,18]. Additionally, surgical emergencies including intestinal obstruction, necrotizing enterocolitis, and intussusception contribute substantially to pediatric morbidity and mortality [19,20]. Malnutrition compounds these risks, adversely affecting recovery and survival [21,22].

Despite evidence linking malnutrition to adverse surgical outcomes, few studies in sub-Saharan Africa have examined its impact on postoperative complications in pediatric gastrointestinal surgery. We hypothesized that (1) preoperative stunting and wasting would be associated with higher odds of postoperative complications and (2) wasting would show a stronger association than stunting. This study, using a detailed dataset from Entebbe, Uganda, aimed to assess the association between preoperative malnutrition and postoperative outcomes, with a specific focus on comparing the effects of wasting and stunting in children aged 1–59 months undergoing major GI surgery.

2. Methods

2.1. Study design and setting

We conducted a retrospective cohort study at the Children's Surgical Hospital (CSH) in Entebbe, Uganda, a specialized pediatric surgical center operated since April 2021 by EMERGENCY, an Italian non-governmental organization. Entebbe lies on a Lake Victoria peninsula approximately 37 km southwest of Kampala. The hospital provides free surgical care to children from across Uganda and neighboring countries and serves as a national reference center for elective pediatric surgery. CSH has 72 beds, including a six-bed pediatric intensive care unit (PICU), a 16-bed high dependency unit, and a general ward, and operates three theatres, performing approximately 1000 surgeries annually [14,23].

2.2. Study population

We included all children aged 1–59 months admitted between April 15, 2021, and November 15, 2024, who underwent major therapeutic GI surgery, as defined by Martin et al. [24], which considers comorbidities, surgical complexity, physiological impact, and clinical outcomes.

Neonates are not managed at the Children's Surgical Hospital and were therefore not eligible for inclusion. Although the hospital admits older children, patients older than 59 months were excluded to focus on the age group for which World Health Organization anthropometric standards and malnutrition classifications are validated and routinely applied, and because both nutritional assessment methods and perioperative risk profiles differ in older pediatric patients [25].

If a patient had more than one admission, only the first record was included.

Patients were excluded from the study if they met any of the following criteria.

- Missing anthropometric data (weight or height/length) at admission.
- Diagnosis of oncologic disease, congenital heart disease, or positive HIV serology at admission, due to potential confounding effects on nutritional status and surgical outcomes.
- Surgery solely for diagnostic purposes (e.g., exploratory laparotomy without therapeutic intervention) or colostomy closure alone, as these procedures are considered minor and generally less impacted by nutritional status.

2.3. Nutritional assessment and classification

At admission, nutritional status was assessed using mid-upper arm circumference (MUAC) and WHO growth standard Z-scores, the WHO 2006 standards for children aged 6–59 months and WHO 2023 standards for children aged 1–5 months, in accordance with WHO malnutrition guidelines recommending their complementary use [26,27]. Z-scores calculated included weight-for-length/height, weight-for-age, and height-for-age. Absolute MUAC thresholds, rather than MUAC-for-age Z-scores, were used in accordance with WHO 2023 operational guidelines, which remain the most widely implemented approach in clinical settings. MUAC was considered an index of malnutrition if it was <110 mm in infants aged 6 weeks to <6 months and <125 mm in children aged 6–59 months [25]. Malnutrition was classified according to the WHO 2023 guidelines [25]. Discharge nutritional status was assessed using the same methods. We did not differentiate moderate from severe malnutrition, as separating them reduced statistical power in preliminary analyses.

2.4. Nutritional rehabilitation

Children with moderate or severe malnutrition received perioperative nutritional rehabilitation, delivered preoperatively, postoperatively, or both, depending on clinical status and surgical timing. Nutritional therapy included enteral feeds (e.g., F-75, F-100, RUTF) or parenteral nutrition when enteral feeding was not feasible. Patients receiving therapy for ≥3 consecutive days were classified as treated. This threshold was chosen to reflect meaningful clinical exposure, consistent with inpatient nutritional stabilization protocols [28].

Preoperative nutritional support was initiated in severely or moderately malnourished patients when surgery could be safely delayed, based on multidisciplinary surgical and pediatric assessment. The duration of preoperative optimization varied with clinical urgency, ranging from same-day initiation to several days before surgery. For children requiring emergency surgery, nutritional therapy was started postoperatively as soon as clinically feasible. We analyzed preoperative and postoperative therapies as separate variables.

2.5. Data collection

Data were extracted from electronic health records and included demographic characteristics, diagnosis, comorbidities, type and urgency of surgery, anthropometric measurements at admission and discharge, admission hemoglobin and albumin levels, details of nutritional therapy, length of hospital stay, length of PICU stay, and occurrence of postoperative complications.

2.6. Outcome measures

The primary outcome was the incidence of postoperative complications, defined as any deviation from the ideal postoperative course that is not inherent to the procedure, and does not comprise failure to cure [29]. Secondary outcomes included the severity of complications, retrospectively classified according to the Clavien–Dindo system [30,31], as well as length of hospital stay, PICU admission and length of PICU stay. We also assessed in-hospital and 30-day postoperative mortality.

2.7. Additional definitions

Anemia in children under 6 years was defined according to WHO criteria as hemoglobin levels below 11.0 g/dL [32]. Admissions were categorized as scheduled (planned elective surgeries) or unscheduled (emergency or urgent surgeries requiring immediate intervention). Comorbidities were defined as pre-existing medical conditions present at admission that could influence outcomes, whereas complications at admission referred to adverse clinical events secondary to the underlying condition occurring prior to surgery. Surgical wounds were classified following CDC and pediatric surgical literature definitions. GI procedures were considered clean-contaminated if the alimentary tract was entered under controlled conditions without gross contamination (e.g., elective colostomy, pull-through for Hirschsprung disease). Procedures were classified as contaminated in cases of fecal spillage, infection, or fecal contamination (e.g., perforated appendicitis, necrotizing enterocolitis with perforation) [33,34].

2.8. Statistical analysis

Descriptive statistics were used to summarize patient demographics, clinical characteristics, nutritional status, surgical details, and outcomes. Continuous variables were reported as means with standard deviations, while categorical variables were expressed as frequencies and percentages.

Comparisons were made between children with and without preoperative malnutrition. Chronic malnutrition (stunting) was defined as a length/height Z-score < -2, and acute malnutrition (wasting) as a weight-for-length/height Z-score < -2. For categorical variables, the chi-square test or Fisher's exact test was applied, as appropriate. For continuous variables, Student's t-test or the Mann–Whitney U test was used based on data normality.

Associations between malnutrition and postoperative outcomes were further assessed using multivariable regression models, applied when univariate analysis showed a potential association ($p < 0.20$). Logistic regression was used for binary outcomes (e.g., occurrence of complications, PICU admission), ordinal logistic regression for complication severity (Clavien–Dindo grade), and linear regression for continuous outcomes (e.g., length of hospital stay, length of PICU stay). Covariates were selected based on clinical and biological plausibility, supported by univariate associations ($p < 0.20$). Age and presence of comorbidities were included given their established clinical relevance across pediatric surgical outcomes [35,36]. Other covariates were evaluated for inclusion based on these criteria on a model-by-model basis. Given the limited number of outcome events, the number of covariates included in each model was restricted to minimize overfitting. Statistical significance was set at $p < 0.05$. We performed analyses using R software (version 4.3.2 for Windows).

We performed sensitivity analyses by restricting the sample to children aged 6–59 months, excluding those with extreme anthropometric Z-scores (below -6 or above $+6$), emergency surgeries, and by focusing on specific conditions, including anorectal malformations and Hirschsprung disease.

Given the sample size and number of outcome events, results should be interpreted with attention to confidence intervals and potential model instability.

2.9. Ethical considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (revised October 2024). Approval was obtained from the Institutional Review Board of EMERGENCY (reference number DS4/2025 EMERGENCY NGO, date 03/09/2025). Given the retrospective nature of the study and the use of anonymized hospital records, the requirement for informed consent was waived.

3. Results

During the observational period, 276 admissions were recorded. We excluded two children due to missing data (Fig. 1). We included 274 records in the study. Among these, 117 (42.7%) were female, with a mean age of 24.5 ± 14.1 months. Table 1 presents the demographic, clinical, biochemical, and nutritional characteristics of the total sample and by sex.

The majority of children, 262 (95.6%), were from Uganda, with the remainder from other Sub-Saharan countries. Anemia, stunting, and wasting were highly prevalent at admission, reported in 185 (67.8%), 107 (39.0%), and 68 (24.8%), respectively. Males presented higher rates of stunting compared to females (45.2% and 30.8%, respectively, $p = 0.02$). No other significant differences were detected between sexes.

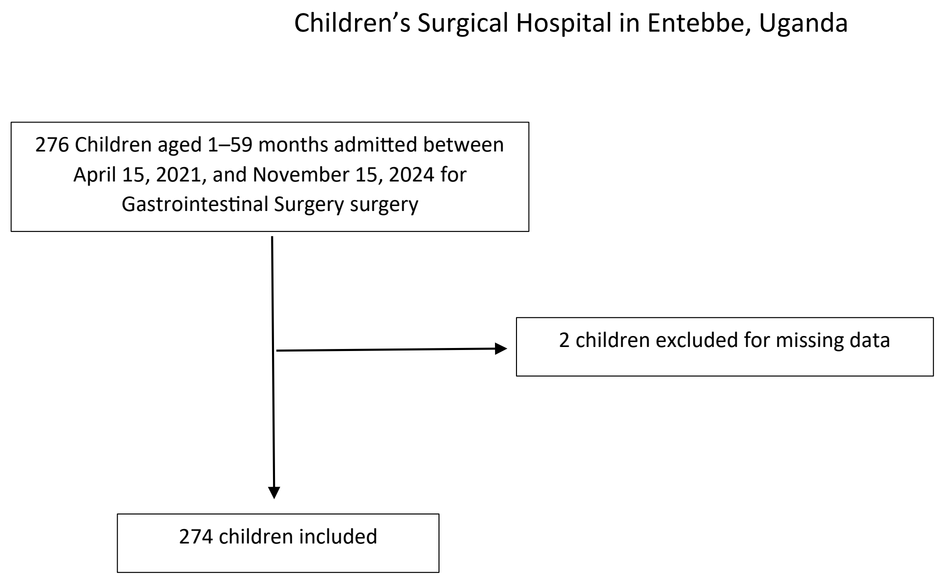

Fig. 1. Flow diagram of participant inclusion and exclusion.

The most prevalent diagnoses at admission were anorectal malformations in 190 (69.3%) children and HD in 64 (23.4%) children. A detailed list of admission diagnoses is provided in Supplementary Table 1 (Table S1).

3.1. Surgery and complications

The most frequently performed surgeries were posterior sagittal anorectoplasty (PSARP) in 177 (64.6%) patients, followed by pull through procedure in 50 (18.2%) children, and stoma formation in 18 (6.6%) patients. Table S2 shows a complete list of surgeries. Thirty-five (12.8%) patients underwent emergency surgery, 21 procedures (16.0%) were classified as contaminated, and 15 (5.8%) had intra-operative complications.

Overall, 95 children (35.6%) experienced at least one postoperative complication, and 21 (7.7%) experienced two, yielding a total of 116 complications. Percentages for individual complications were calculated relative to this total. Wound infection or dehiscence occurred in 62 cases (53.4%) and urinary tract infections in 25 (21.6%). Table S3 lists the postoperative complications. There were six fatalities (2.2%), all occurring more than 30 days after hospital discharge and not reported as directly related to the index surgical procedure in the available records.

3.2. Comparative analysis: stunting vs. wasting

In univariate analyses, stunted children had higher comorbidity prevalence (30.8% vs 15.6%, $p = 0.003$) and received nutritional support more frequently both before (7.9% vs 2.5%, $p = 0.04$) and after surgery (14.9% vs 5.6%, $p = 0.01$) compared with non-stunted peers (Table 2). Wasted children were younger (19.4 vs 25.6 months, $p < 0.001$), had more unscheduled admissions (30.9% vs 10.2%, $p < 0.001$), underwent emergency or complicated surgeries more often (27.9% vs 7.8% and 30.6% vs 10.5%, $p < 0.01$), and received more perioperative nutritional therapy (preoperative 16.4% vs 1.0%, postoperative 29.5% vs 3.0%, both $p < 0.001$). Wasted children also had longer PICU stays (4.6 vs 1.6 days, $p = 0.04$) (Table 3).

After adjusting for potential confounders (Tables 4 and 5), wasting—but not stunting—was independently associated with postoperative complications (OR 3.74, 95% CI 1.14–13.38, $p = 0.03$) (Fig. 2). Trends toward longer PICU stay and increased complication severity were observed in wasted children, though these did not reach statistical significance (Table 5).

3.3. Sensitivity analyses

The association between wasting and postoperative complications remained significant when children with extreme anthropometric Z-scores (below −6 or above +6) were excluded. The results were generally consistent when restricting the analysis to children aged 6–59 months. However, the association was not statistically significant when excluding emergency surgeries or when considering only children with Hirschsprung disease (Table S4).

4. Discussion

4.1. Key findings

This study provides a detailed assessment of malnutrition and postoperative outcomes in children undergoing abdominal surgery in a Sub-Saharan African country. Among children aged 1–59 months, 39.0% were stunted and 24.8% wasted at admission. Male children exhibited higher rates of stunting, consistent with evidence that boys are more vulnerable to chronic nutritional stress in high-risk settings. Importantly, wasting, but not stunting, was independently associated with an increased risk of postoperative complications, even after adjusting for age, sex, and perioperative nutritional interventions, highlighting acute malnutrition as a critical determinant of surgical risk.

4.2. Prevalence of malnutrition and gender differences

The prevalence of malnutrition in our cohort was considerably higher than national averages in Uganda, where wasting affects 2.9% and stunting 26% of children under five years [2]. Hospitalized children are at higher risk of malnutrition [37], and children requiring surgery may represent a particularly vulnerable subgroup, potentially due to prolonged illness, feeding difficulties, or delays in accessing appropriate care.

Table 1
Demographic, clinical, biochemical and nutritional characteristics of the total sample and by sex. Data are presented as frequency (percentile) or mean (SD) or median (IQR).

	Female (n = 117)		Male (n = 157)		Total sample (n = 274)		p-value
	NoM	N (%)	NoM	N (%)	NoM	N (%)	
Baseline characteristics							
Age in months, mean (± SD)	117	23.2 (14.0)	157	25.5 (14.1)	274	24.5 (14.1)	0.2
Unscheduled admission	117	15 (12.8)	157	27 (17.2)	274	42 (15.3)	0.3
Comorbidities at admission	117	22 (18.8)	157	37 (23.6)	274	59 (21.5)	0.3
Complications at admission	117	33 (28.2)	157	46 (29.3)	274	79 (28.8)	0.8
Ugandan nationality	117	114 (97.4)	157	148 (94.3)	274	262 (95.6)	0.2
Biochemical characteristics							
Anemia	117	75 (64.1)	156	110 (70.5)	273	185 (67.8)	0.3
Hemoglobin g/dL, mean (± SD)	117	10.4 (1.4)	156	10.1 (1.8)	273	10.2 (1.6)	0.2
Albumin g/dL, mean (± SD)	117	4.0 (0.4)	156	3.9 (0.4)	273	3.9 (0.4)	0.9
Surgery							
Emergency surgery	117	13 (11.1)	157	22 (14.0)	274	35 (12.8)	0.5
Contaminated surgery	45	9 (20.0)	86	12 (14.0)	131	21 (16.0)	0.4
Intra-operative complications	107	5 (4.7)	150	10 (6.7)	257	15 (5.8)	0.5
Nutritional status and support							
Stunting at admission	117	36 (30.8)	157	71 (45.2)	274	107 (39.0)	0.02
Wasting at admission	117	33 (28.2)	157	35 (22.3)	274	68 (24.8)	0.3
Wasting at discharge	104	20 (19.2)	145	24 (16.6)	249	44 (17.7)	0.6
Nutritional rehabilitation before admission	75	2 (2.7)	107	4 (3.7)	182	6 (3.3)	1
Nutritional support before surgery	112	4 (3.6)	150	8 (5.3)	262	12 (4.6)	0.6
Nutritional support after surgery	112	7 (6.2)	150	17 (11.3)	262	24 (9.1)	0.2
Outcomes							
Postoperative complications	115	38 (33.0)	152	57 (37.5)	269	95 (35.6)	0.5
Grade of postoperative complication (Clavien Dindo I–V), median (IQR)	37	1.8 (1.3)	59	1.6 (1.2)	96	1 (1–2)	0.6
Hospitalization days, mean (± SD)	117	26 (33.6)	157	24.6 (11.4)	274	25.2 (23.5)	0.7
PICU stay	117	51 (43.6)	156	65 (41.0)	274	115 (42.1)	0.7
Days of PICU stay, mean (± SD)	51	2.0 (3.5)	64	2.3 (3.3)	115	2.2 (3.4)	0.6
Deaths[a]	117	3 (2.6)	157	3 (1.9)	274	6 (2.2)	0.7

Abbreviations.
NoM, Number of measurements.
IQR, Interquartile Range.
PICU, Pediatric Intensive Care Unit.
SD, Standard Deviation.
[a] These deaths occurred >30 days after discharge and were not reported as directly related to the index surgical procedure in available records.

Table 2
Baseline, clinical and biochemical characteristics, and outcomes by stunting at admission.

	Not Stunted at admission (n = 167)		Stunted at admission (n = 107)		p-value
	NoM	N (%)	NoM	N (%)	
Baseline characteristics					
Female sex	167	81 (48.5)	107	36 (33.6)	0.02
Age in months, mean (SD)	167	23.7 (14.4)	107	25.8 (13.4)	0.2
Unscheduled admission	167	28 (16.8)	107	14 (13.1)	0.4
Comorbidities at admission	167	26 (15.6)	107	33 (30.8)	0.003
Complications at admission	167	49 (29.3)	107	30 (28.0)	0.8
Biochemical characteristics					
Anemia	166	109 (65.7)	107	76 (71.0)	0.4
Hemoglobin g/dL, mean (± SD)	166	10.3 (1.7)	107	10.4 (1.6)	0.3
Albumin g/dL, mean (± SD)	166	4.0 (0.4)	107	3.9 (0.5)	0.2
Surgery					
Emergency surgery	167	25 (15.0)	107	10 (9.3)	0.2
Contaminated surgery	81	15 (18.5)	50	6 (12.0)	0.3
Intra-operative complications	156	7 (4.5)	101	8 (7.9)	0.3
Nutritional status and support					
Wasting at admission	167	41 (24.6)	107	27 (25.2)	0.9
Wasting at discharge	151	27 (17.9)	98	17 (17.3)	0.9
Nutritional rehabilitation before admission	115	1 (0.9)	67	5 (7.5)	0.01
Nutritional support before surgery	161	4 (2.5)	101	8 (7.9)	0.04
Nutritional support after surgery	161	9 (5.6)	101	15 (14.9)	0.01
Outcomes					
Postoperative complications	164	53 (32.3)	103	42 (40.8)	0.2
Grade of postoperative complication (Clavien Dindo I–V), median (IQR)	55	2 (1–2)	41	2 (1–2)	0.5
Hospitalization days, mean (± SD)	167	26.0 (29.2)	107	24.0 (9.6)	0.4
PICU stay	167	70 (41.9)	106	45 (42.5)	0.9
Days of PICU stay, mean (± SD)	97	2.1 (3.2)	62	2.3 (3.7)	0.8
Deaths[a]	167	4 (2.4)	107	2 (1.9)	1

Abbreviations.
NoM, Number of measurements.
IQR, Interquartile Range.
PICU, Pediatric Intensive Care Unit.
SD, Standard Deviation.
[a] These deaths occurred >30 days after discharge and were not reported as directly related to the index surgical procedure in available records.

Our findings are in line with reports from other Sub-Saharan African countries. In Rwanda, a prospective study of surgical children aged 1 month to 15 years found stunting in 26.9% and wasting in 21.2% [38]. In Zimbabwe, preoperative children under 18 years had prevalence rates of 22% and 12% for stunting and wasting, respectively [39]. In Ethiopia, a tertiary hospital study reported 45% malnutrition among pediatric surgical patients aged 1 month to 14 years [40]. By contrast, proportions in high-income settings are lower: in the United States, preoperative malnutrition affected 19% of children 0–18 years, with a peak stunting prevalence of 32% in infants [41]. This discrepancy likely reflects differences in socioeconomic conditions and access to care — particularly the availability of early diagnosis, timely identification of nutritional deficits, and access to preoperative nutritional support.

We also observed higher rates of stunting among male children, consistent with regional and global evidence. Demographic and Health Surveys across Sub-Saharan Africa, including Uganda, consistently show higher stunting prevalence in boys than girls [42–44]. This may reflect both biological and environmental factors: male children have greater energy requirements, are more susceptible to infections, and experience slower immune maturation [45]. A systematic review by Thurstans et al. [46] confirmed that boys are consistently more likely to be undernourished than girls, especially in settings with high exposure to nutritional and infectious stressors. In surgical contexts, these vulnerabilities may amplify nutritional risk, which could explain the higher prevalence of stunting among male patients in our cohort.

Table 3
Baseline, clinical and biochemical characteristics, and outcomes by wasting at admission.

	Not Wasted at admission (n = 206)		Wasted at admission (n = 68)		p-value
	NoM	N (%)	NoM	N (%)	
Baseline characteristics					
Female sex	206	84 (40.8)	68	33 (48.5)	0.3
Age in months, mean (SD)	206	26.2 (14.4)	68	19.4 (11.6)	<0.001
Unscheduled admission	206	21 (10.2)	68	21 (30.9)	<0.001
Comorbidities at admission	206	37 (18.0)	68	22 (32.4)	0.01
Complications at admission	206	55 (26.7)	68	24 (35.3)	0.2
Biochemical characteristics					
Anemia	205	138 (67.3)	68	47 (69.1)	0.8
Hemoglobin g/dL, mean (± SD)	205	10.3 (1.6)	68	10.1 (1.7)	0.4
Albumin g/dL, mean (± SD)	205	4.0 (0.4)	68	3.9 (0.5)	0.7
Surgery					
Emergency surgery	206	16 (7.8)	68	19 (27.9)	<0.001
Contaminated surgery	95	10 (10.5)	36	11 (30.6)	0.005
Intra-operative complications	197	12 (6.1)	60	3 (5.0)	1
Nutritional status and support					
Stunting at admission	206	80 (38.8)	68	27 (39.7)	0.9
Wasting at discharge	188	7 (3.7)	61	37 (60.7)	<0.001
Nutritional rehabilitation before admission	141	4 (2.8)	41	2 (4.9)	0.5
Nutritional support before surgery	201	2 (1.0)	61	10 (16.4)	<0.001
Nutritional support after surgery	201	6 (3.0)	61	18 (29.5)	<0.001
Outcomes					
Postoperative complications	201	66 (32.8)	66	29 (43.9)	0.1
Grade of postoperative complication (Clavien Dindo I–V), median (IQR)	67	1 (1–2)	29	1 (1–3)	0.5
Hospitalization days, mean (± SD)	206	24.0 (10.5)	68	28.7 (43.3)	0.4
PICU stay	205	92 (44.9)	68	23 (33.8)	0.1
Days of PICU stay, mean (± SD)	92	1.6 (1.2)	45	4.6 (6.7)	0.04
Deaths[a]	206	3 (1.5)	68	3 (4.4)	0.2

Abbreviations.
NoM, Number of measurements.
IQR, Interquartile Range.
PICU, Pediatric Intensive Care Unit.
SD, Standard Deviation.
[a] All reported deaths occurred more than 30 days after hospital discharge and were unrelated to the initial surgical admission.

4.3. Impact of malnutrition on surgical outcomes

The association between wasting and postoperative complications is consistent with studies in both pediatric and adult populations [6,7,39]. In adults undergoing gastrointestinal surgery, malnutrition has been shown to predict longer hospital stays, higher mortality, and more postoperative complications [6]. In

Table 4
Multivariate analyses assessing correlation between admission stunting and clinical outcomes.

Logistic regression using postoperative complication as dependent variable				
Independent variables	OR	95% CI	p-value	
Stunting at admission	1.28	0.65–2.52	0.6	
Male sex	1.32	0.68–2.59	0.5	
Age in months	0.97	0.95–0.99	0.02	
Comorbidity at admission	0.77	0.29–1.93	0.6	
Nutritional rehabilitation before admission	0.26	0.01–1.85	0.2	
Nutritional support before surgery	0.68	0.10–4.22	0.7	
Nutritional support after surgery	4.19	1.17–17.94	0.03	
Logistic regression using PICU admission as dependent variable				
Independent variables	**OR**	**95% CI**	**p-value**	
Stunting at admission	0.98	0.51–1.86	0.8	
Male sex	1.14	0.61–2.14	0.1	
Age in months	0.98	0.96–1.00	0.9	
Comorbidity at admission	0.95	0.39–2.29	0.9	
Nutritional rehabilitation before admission	1.61	0.26–10.75	0.6	
Nutritional support before surgery	0.01	0.00–0.57	0.03	
Nutritional support after surgery	2.08	0.60–8.32	0.3	
Ordinal logistic regression using grade of postoperative complication (Clavien Dindo I–V as dependent variable				
Independent variables	**Estimate**	**95% CI**	**t-value**	**SE**
Stunting at admission	−0.70	−1.68/0.26	−1.42	0.49
Male sex	.-0.03	−0.97/0.91	−0.07	0.47
Age in months	−0.02	−3.45/3.41	−1.07	0.02
Comorbidity at admission	−0.58	−1.99/0.76	−0.83	0.69
Nutritional rehabilitation before admission	−0.02	−3.45/3.41	−0.01	1–56
Nutritional support before surgery	1.11	−0.93/3.16	1.10	1–01
Nutritional support after surgery	−1.69	−3.20/ −0.30	−2.33	0.72
Linear regression using hospitalization days as dependent variable				
Independent variables	**Beta-estimates**	**95% CI**	**p-value**	**SE**
Stunting at admission	−0.29	−3.78/3.19	0.9	2.01
Male sex	1.98	−1.40/5.35	0.2	1.71
Age in months	0.01	−0.11/0.12	0.9	0.06
Comorbidity at admission	0.63	−4.11/5.36	0.8	2.40
Nutritional rehabilitation before admission	−8.68	−18.04/ 0.67	0.07	4.74
Nutritional support before surgery	0.35	−8.94/9.63	0.9	4.70
Nutritional support after surgery	4.24	−2.43/ 10.90	0.2	3.4
Linear regression using days of PICU stay as dependent variable				
Independent variables	**Beta-estimates**	**95% CI**	**p-value**	**SE**
Stunting at admission	0.52	−1.01/2.05	0.5	0.77
Male sex	0.06	−1.43/1.55	0.9	0.74
Age in months	−0.04	−0.09/0.01	0.1	0.03
Comorbidity at admission	−1.93	−3.98/0.11	0.06	1.02
Nutritional rehabilitation before admission	−0.02	−3.73/3.70	1	1.86
Nutritional support before surgery	−9.93	−16.78/ −3.09	0.005	3.43
Nutritional support after surgery	9.00	6.50/11.50	<0.001	1.25

Abbreviations.
CI, confidence intervals.
OR, odds ratio.
PICU, pediatric intensive care unit.

Table 5
Multivariate analyses assessing correlation between admission wasting and clinical outcomes.

Logistic regression using postoperative complication as dependent variable				
Independent variables	OR	95% CI	p-value	
Wasting at admission	3.74	1.14–13.38	0.03	
Age in months	0.98	0.94–1.01	0.1	
Unscheduled admission	0.17	0.00–2.42	0.3	
Comorbidity at admission	0.35	0.09–1.20	0.1	
Complication at admission	4.21	1.73–10.78	0.002	
Emergency surgery	3.96	0.13–133.10	0.5	
Contaminated surgery	0.35	0.04–2.55	0.1	
Nutritional support before surgery	0.35	0.04–2.54	0.3	
Nutritional support after surgery	4.69	1.04–25.17	0.05	
Logistic regression using PICU admission as dependent variable				
Independent variables	**OR**	**95% CI**	**p-value**	
Wasting at admission	0.49	0.14–1.51	0.2	
Age in months	0.99	0.97–1.02	0.7	
Comorbidity at admission	0.38	0.09–1.30	0.2	
Complication at admission	1.16	0.51–2.60	0.7	
Contaminated surgery	1.79	0.59–5.39	0.3	
Nutritional support before surgery	0.08	0.00–0.72	0.05	
Nutritional support after surgery	5.84	1.40–29.26	0.02	
Ordinal logistic regression using grade of postoperative complication (Clavien Dindo I–V as dependent variable				
Independent variables	**Estimate**	**95% CI**	**t-value**	**SE**
Wasting at admission	−0.71	−2.27/0.86	−0.89	0.79
Age in months	−0.03	−0.09/0.02	−1.29	0.03
Unscheduled admission	0.12	−1.67/1.99	0.13	0.91
Comorbidity at admission	−1.17	−3.46/0.89	−1.09	1.07
Complication at admission	0.10	−1.06/1.28	0.17	0.59
Contaminated surgery	0.91	−1.65/3.54	0.70	1.30
Nutritional support before surgery	1.27	−0.97/3.63	1.11	1.14
Nutritional support after surgery	−1.72	−3.72/0.10	−1.80	0.95
Linear regression using hospitalization days as dependent variable				
Independent variables	**Beta-estimates**	**95% CI**	**p-value**	**SE**
Wasting at admission	4.35	−0.87/9.57	0.1	2.64
Age in months	0.06	−0.08/0.20	0.4	0.07
Unscheduled admission	−5.51	−12.96/1.95	0.1	3.77
Comorbidity at admission	−0.71	−6.10/4.69	0.8	2.72
Complication at admission	4.86	0.75/8.97	0.02	2.08
Contaminated surgery	6.89	−0.15/13.93	0.06	3.56
Nutritional support before surgery	−2.85	−12.05/6.36	0.5	4.65
Nutritional support after surgery	−7.05	−13.63/−0.47	0.04	3.33
Linear regression using days of PICU stay as dependent variable				
Independent variables	**Beta-estimates**	**95% CI**	**p-value**	**SE**
Wasting at admission	3.43	−0.66/7.51	0.1	2.01
Age in months	−0.07	−0.16/0.03	0.2	0.05
Unscheduled admission	−3.12	−9.23/2.99	0.3	3.01
Comorbidity at admission	−3.38	−8.14/1.38	0.2	2.34
Complication at admission	1.17	−1.56/3.91	0.4	1.35
Contaminated surgery	5.79	1.23/10.35	0.01	2.24
Nutritional support before surgery	−9.58	−18.49/−0.66	0.04	4.39
Nutritional support after surgery	3.34	−2.30/8.98	0.2	2.78

Abbreviations.
CI, confidence intervals.
OR, odds ratio.
PICU, pediatric intensive care unit.

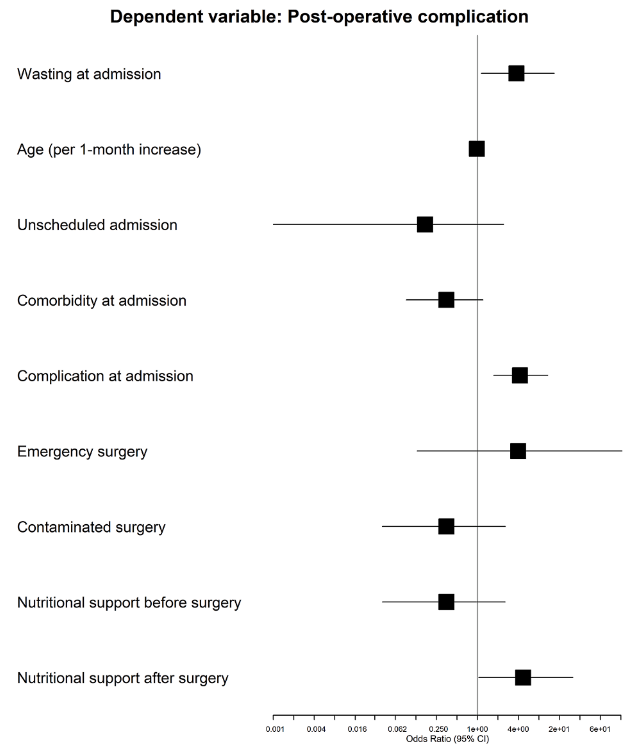

Fig. 2. Odds ratio (ORs) plot from logistic regression analysis with postoperative complications as the dependent variable.
ORs and 95% confidence intervals (CIs) are presented on a logarithmic scale. The reference group is non-wasted children. Estimates are adjusted for age (months), unscheduled admission, comorbidity at admission, complication at admission, emergency surgery, contaminated surgery, and pre- and postoperative nutritional support.

Zimbabwe, undernourished surgical children aged 0–18 years were four to six times more likely to develop postoperative complications. The study classified children as undernourished using the lowest Z-score across multiple anthropometric indicators (BMI-for-age, height-for-age, weight-for-age, MUAC-for-age, and weight-for-height), without distinguishing between acute and chronic malnutrition [39].

From a biological perspective, acute malnutrition—particularly deficiencies in micronutrients such as zinc and vitamin A—reduces the body's ability to mount an effective immune response. Protein deficiency further impairs immune cell production and function, weakening host defense mechanisms. Insufficient intake of dietary fats, especially essential fatty acids, may disrupt immune regulation and promote chronic inflammation, ultimately compromising overall immune function [9]. Adequate macro- and micronutrients, along with hydration, are essential to support the anabolic processes required for wound healing. Nutrient deprivation triggers metabolic adaptations, including increased metabolic rate and elevated cortisol levels, which promote protein catabolism, fat mobilization, and heightened inflammatory responses, collectively impairing tissue repair and delaying wound healing [47].

Acute malnutrition is also strongly associated with invasive bacterial infections. Hospitalized children with severe wasting in Sub-Saharan Africa have a two-to threefold higher risk of bacteremia compared with well-nourished peers, often caused by Gram-negative enteric pathogens. Impaired immunity, combined with disruption of the gut mucosal barrier, facilitates microbial translocation into the bloodstream [48]. In children undergoing abdominal surgery, these factors likely amplify susceptibility to postoperative sepsis and infectious complications [9].

We did not find an association between stunting and postoperative complications. These results differ from those of a prospective study in pediatric patients aged 1–60 months undergoing GI surgery, which identified a higher prevalence of stunting among children with at least one postoperative complication, whereas wasting showed no such association [49]. Differences in methodology and context may partly account for the divergence from our findings, including variation in study design, sample size, surgical case mix, perioperative nutrition, and baseline population characteristics. Koofy et al. [49] did not perform multivariate analyses and used a different growth chart to define malnutrition (the 2000 Centers for Disease Control and Prevention growth charts).

Stunting reflects chronic or recurrent undernutrition beginning early in life and is associated with long-term immune dysregulation and epigenetic changes [9]; however, it may represent a more metabolically adapted state with less immediate impact on surgical recovery, whereas wasting reflects acute metabolic and immunologic stress that directly impairs wound healing and resistance to infection [48]. These mechanistic interpretations remain speculative and cannot be confirmed in our dataset but may guide future mechanistic or interventional work.

We also found no association between malnutrition and length of hospital stay. In contrast, a study from Rwanda reported longer hospitalizations among children with moderate wasting and severe stunting [38]. This may reflect differences in study population (our cohort focused exclusively on abdominal surgery) and in methodological choices. Seneza et al. [38] modeled moderate and severe malnutrition as separate dummy variables, whereas we applied a dichotomous classification to preserve statistical power. Our approach may have reduced sensitivity to detect risk gradients, but it allowed clearer comparison between malnourished and non-malnourished children.

4.4. Clinical implications

Our results support systematic perioperative nutritional screening using MUAC and WHO Z-scores, with particular attention to identifying children with wasting. Elective surgery should, when feasible, be delayed to allow short-term nutritional rehabilitation. This strategy aligns with perioperative nutrition guidelines and ERAS principles, which emphasize early identification of nutritional risk, minimization of preoperative fasting, and timely nutritional intervention as modifiable determinants of surgical outcomes, particularly among patients undergoing major gastrointestinal procedures [8].

Trials evaluating structured perioperative feeding protocols, including preoperative therapeutic feeding and early postoperative supplementation, are needed to determine their effectiveness in reducing surgical risk and enhancing recovery. Such targeted interventions represent a low-cost and potentially high-impact strategy to reduce postoperative complications among children with acute malnutrition.

4.5. Strengths and limitations

This study provides the pioneering dataset examining malnutrition and postoperative outcomes in children undergoing major GI surgery in Uganda. Although similar associations between undernutrition and surgical risk have been reported elsewhere, our study extends this evidence to a Ugandan pediatric GI surgical cohort and underscores the feasibility of implementing systematic nutritional screening and perioperative support in such a setting. These findings may extend beyond gastrointestinal procedures and the study setting, as the relationship between wasting, impaired immunity, and increased susceptibility to infection likely applies across a broad spectrum of major pediatric surgeries. Furthermore, undernutrition and barriers to timely surgical care are common across many LMICs; therefore, the benefits of systematic nutritional screening, preoperative rehabilitation, and structured perioperative feeding protocols may be generalizable to comparable resource-limited contexts.

This retrospective, single-center study cannot establish causality, and the findings should therefore be interpreted as associations. The modelling strategy may have resulted in residual confounding and unstable estimates due to the small number of events. A limited events-per-variable ratio may have contributed to reduced power and unstable estimates, as reflected in wide confidence intervals. Some patients traveled internationally for surgery, potentially introducing selection bias. Nutritional rehabilitation was defined as $\geq$3 consecutive days of therapy; however, this metric does not capture adequacy, timing, or adherence of nutritional support. Retrospective grading of complications may have led to underestimation of lower-grade events due to incomplete or inconsistent documentation. Long-term outcomes, including readmissions and postdischarge survival, were not assessed, and complications occurring after discharge may have been incompletely captured. Although clinical variables were included in the analyses, residual confounding related to disease severity, intercurrent infection at admission, socioeconomic conditions, and feeding practices cannot be excluded. Anthropometric measurements, particularly in critically ill children, may also be subject to observer-dependent variability. While sensitivity analyses addressed potential confounding by surgical indication and timing, residual confounding may persist.

5. Conclusion

Acute malnutrition is associated with an increased risk of postoperative complications in pediatric abdominal surgery, whereas chronic malnutrition reflects underlying vulnerability without directly increasing surgical risk. These findings underscore the critical role of perioperative nutritional assessment and targeted intervention. This includes integrating systematic nutritional screening, using MUAC and standard anthropometric assessments, into routine pre-surgical checklists and prioritizing preoperative nutritional rehabilitation for wasted children when surgery can be safely deferred. Postoperatively, early enteral feeding and structured nutritional follow-up should be embedded into standard care pathways, as these measures may help reduce morbidity and improve recovery. Future research should test these targeted interventions, such as preoperative stabilization with therapeutic feeds and early postoperative supplementation, and evaluate their impact on complications and recovery trajectories.

Availability of data and material

Data available upon reasonable request.

Authors contributions

BE, GM, ALV and CB conceptualized and designed the study. ALV designed the data collection instruments. BE and GC collected data. ALV was responsible for the analysis and interpretation of data. BE and ALV drafted the manuscript. CA and CB performed a critical revision of the manuscript and gave a significant contribution in their field of expertise. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Ethics approval

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki, as revised in October 2024. The Ethical Committee of Institutional Review Board of EMERGENCY approved the study (reference number DS4/2025 EMERGENCY NGO, date 03/09/2025), which included a waiver of informed consent because of the retrospective nature of the investigation.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors used Gemini (Google AI) in order to improve the flow of the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2026.103366.

References

[1] World Health Organization. United Nations Children's Fund (UNICEF), World Health Organization, International Bank for Reconstruction and Development/The World Bank. Levels and trends in child malnutrition: UNICEF/WHO/World bank group joint child malnutrition estimates. Key findings of the 2025 edition. 2025.

[2] Uganda Bureau of Statistics. Uganda demographic and health survey 2022 volume 1. Kampala; 2023 [Uganda: UBOS. n.d.].

[3] United Nations Children's Fund (UNICEF)Uganda. Uganda annual report 2024 – nutrition and humanitarian response. Kampala: Unicef Uganda; 2025.

[4] Nsubuga EJ, Arinda Kato I, Lee S, Ssenyondo M, Isunju JB. Predictors of stunting and underweight among children aged 6 to 59 months in bussi islands, Wakiso district, Uganda: a cross-sectional study. Nutr Metab Insights 2022;15. https://doi.org/10.1177/11786388221125107. 11786388221125107.

[5] Ministry of Health, Uganda. Guidelines for integrated management of acute malnutrition in Uganda. 2020 [n.d.].

[6] Ho JWC, Wu AHW, Lee MWK, Lau S, Lam P, Lau W, et al. Malnutrition risk predicts surgical outcomes in patients undergoing gastrointestinal operations: results of a prospective study. Clin Nutr 2015;34:679–84. https://doi.org/10.1016/j.clnu.2014.07.012.

[7] Wessner S, Burjonrappa S. Review of nutritional assessment and clinical outcomes in pediatric surgical patients: does preoperative nutritional assessment impact clinical outcomes? J Pediatr Surg 2014;49:823–30. https://doi.org/10.1016/j.jpedsurg.2014.01.006.

[8] Lobo DN, Gianotti L, Adiamah A, Barazzoni R, Deutz NEP, Dhatariya K, et al. Perioperative nutrition: recommendations from the ESPEN expert group. Clin Nutr 2020;39:3211–27. https://doi.org/10.1016/j.clnu.2020.03.038.

[9] Morales F, Montserrat-de La Paz S, Leon MJ, Rivero-Pino F. Effects of malnutrition on the immune system and infection and the role of nutritional strategies regarding improvements in children's health status: a literature review. Nutrients 2023;16:1. https://doi.org/10.3390/nu16010001.

[10] Martins DS, Piper HG. Nutrition considerations in pediatric surgical patients. Nutr Clin Pract 2022;37:510–20. https://doi.org/10.1002/ncp.10855.

[11] Wischmeyer PE, Carli F, Evans DC, Guilbert S, Kozar R, Pryor A, et al. American society for enhanced recovery and perioperative quality initiative joint consensus statement on nutrition screening and therapy within a surgical enhanced recovery pathway. Anesth Analg 2018;126:1883–95. https://doi.org/10.1213/ANE.0000000000002743.

[12] Freijer K, Van Puffelen E, Joosten KF, Hulst JM, Koopmanschap MA. The costs of disease related malnutrition in hospitalized children. Clin Nutr ESPEN 2018;23:228–33. https://doi.org/10.1016/j.clnesp.2017.09.009.

[13] Mazaki T, Ebisawa K. Enteral versus parenteral nutrition after gastrointestinal surgery: a systematic review and meta-analysis of randomized controlled trials in the English literature. J Gastrointest Surg 2008;12:739–55. https://doi.org/10.1007/s11605-007-0362-1.

[14] Alberti P, Kisa P. Paediatric surgery in Uganda: current challenges and opportunities. Discov Health Syst 2024;3. https://doi.org/10.1007/s44250-024-00076-8.

[15] Lawal TA. Overview of anorectal malformations in Africa. Front Surg 2019;6:7. https://doi.org/10.3389/fsurg.2019.00007.

[16] Kayima P, Kitya D, Punchak M, Anderson GA, Situma M. Patterns and treatment outcomes of anorectal malformations in Mbarara regional referral hospital, Uganda. J Pediatr Surg 2019;54:838–44. https://doi.org/10.1016/j.jpedsurg.2018.07.019.

[17] Trinidad S, Kayima P, Kotecha V, Massenga A, Rymeski B, Frischer JS, et al. Hirschsprung's disease in low- and middle-income countries. Semin Pediatr Surg 2022;31:151163. https://doi.org/10.1016/j.sempedsurg.2022.151163.

[18] Mabula JB, Kayange NM, Manyama M, Chandika AB, Rambau PF, Chalya PL. Hirschsprung's disease in children: a five year experience at a university teaching hospital in northwestern Tanzania. BMC Res Notes 2014;7:410. https://doi.org/10.1186/1756-0500-7-410.

[19] Twahirwa I, Ndayiragije C, Nyundo M, Rickard J, Ntaganda E. Pediatric intestinal obstruction: analysis of etiologies and factors influencing short-term outcomes in Rwanda. World J Pediatr Surg 2022;5:e000424. https://doi.org/10.1136/wjps-2022-000424.

[20] Pindyck T, Parashar U, Mwenda JM, Tadesse A, Armah G, Omore R, et al. Risk factors associated with increased mortality from intussusception in African infants. J Pediatr Gastroenterol Nutr 2020;70:20–4. https://doi.org/10.1097/MPG.0000000000002487.

[21] Abbas A, Laverde R, Yap A, Stephens CQ, Samad L, Seyi-Olajide JO, et al. Routine pediatric surgical emergencies: incidence, morbidity, and mortality during the 1st 8000 days of Life-A narrative review. World J Surg 2023;47:3419–28. https://doi.org/10.1007/s00268-023-07097-z.

[22] Ekenze SO, Mgbor SO. Childhood intussusception: the implications of delayed presentation. Afr J Paediatr Surg AJPS 2011;8:15–8. https://doi.org/10.4103/0189-6725.78662.

[23] EMERGENCY – children's surgical hospital in entebbe. https://en.emergency.it/projects/uganda-entebbe-paediatric-surgery-centre/.

[24] Martin D, Mantziari S, Demartines N, Hübner M, Bismuth H, et al. Defining major surgery: a Delphi consensus among european surgical association (ESA) members. World J Surg 2020;44:2211–9. https://doi.org/10.1007/s00268-020-05476-4.

[25] WHO guideline on the prevention and management of wasting and nutritional oedema (acute malnutrition) in infants and children under 5 years. Geneva: World Health Organization; 2023.

[26] WHO Multicentre Growth Reference Study Group. WHO child growth standards based on length/height, weight and age. Acta Paediatr Oslo Nor 1992 Suppl 2006;450:76–85. https://doi.org/10.1111/j.1651-2227.2006.tb02378.x.

[27] WHO 2023. World health organization. Management of infants under 6 months of age with severe acute malnutrition. www.who.int.. 2023. https://www.who.int/tools/elena/interventions/sam-infants.

[28] Chiopris G, Gervasoni A, Valenti M. EMERGENCY Internal Pediatric guidelines. Milan, Italy: EMERGENCY; 2023; 2023.

[29] Dindo D, Clavien P-A. What is a surgical complication? World J Surg 2008;32:939–41. https://doi.org/10.1007/s00268-008-9584-y.

[30] Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205–13. https://doi.org/10.1097/01.sla.0000133083.54934.ae.

[31] Clavien PA, Barkun J, De Oliveira ML, Vauthey JN, Dindo D, Schulick RD, et al. The clavien-dindo classification of surgical complications: five-year experience. Ann Surg 2009;250:187–96. https://doi.org/10.1097/SLA.0b013e3181b13ca2.

[32] World Health Organization. In: Guideline on haemoglobin cutoffs to define anaemia in individuals and populations. Geneva: World Health Organization; 2024.

[33] Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, et al. Centers for disease control and prevention guideline for the prevention of surgical site infection, 2017. JAMA Surg 2017;152:784. https://doi.org/10.1001/jamasurg.2017.0904.

[34] Zens TJ, Rusy DA, Gosain A. Pediatric surgeon–directed wound classification improves accuracy. J Surg Res 2016;201:432–9. https://doi.org/10.1016/j.jss.2015.11.051.
[35] Brock R, Chu A, Lu S, Brindle ME, Somayaji R. Postoperative complications after gastrointestinal pediatric surgical procedures: outcomes and socio-demographic risk factors. BMC Pediatr 2022;22:358. https://doi.org/10.1186/s12887-022-03418-8.
[36] Tejwani R, Lee H-J, Hughes TL, Hobbs KT, Aksenov LI, Scales CD, et al. Predicting postoperative complications in pediatric surgery: a novel pediatric comorbidity index. J Pediatr Urol 2022;18:291–301. https://doi.org/10.1016/j.jpurol.2022.03.007.
[37] Pawellek I, Dokoupil K, Koletzko B. Prevalence of malnutrition in paediatric hospital patients. Clin Nutr Edinb Scotl 2008;27:72–6. https://doi.org/10.1016/j.clnu.2007.11.001.
[38] Seneza C, McIsaac DI, Twagirumugabe T, Bould MD. A prospective, cohort study of the effect of acute and chronic malnutrition on length of stay in children having surgery in Rwanda. Anesth Analg 2022;135:152–8. https://doi.org/10.1213/ANE.0000000000005956.
[39] Bergkvist E, Zimunhu T, Mbanje C, Hagander L, Muguti GI. Nutritional status and outcome of surgery: a prospective observational cohort study of children at a tertiary surgical hospital in Harare, Zimbabwe. J Pediatr Surg 2021;56:368–73. https://doi.org/10.1016/j.jpedsurg.2020.09.020.
[40] Wondemagegnehu BD, Aklilu WK, Beyene MD, Nonyane BAS. Impact of malnutrition on the outcome and length of hospital stay in elective pediatric surgical patients: prospective cohort study at tertiary hospitals in Ethiopia. BMC Nutr 2023;9:127. https://doi.org/10.1186/s40795-023-00788-9.
[41] Roberson ML, Egberg MD, Strassle PD, Phillips MR. Measuring malnutrition and its impact on pediatric surgery outcomes: a NSQIP-P analysis. J Pediatr Surg 2021;56:439–45. https://doi.org/10.1016/j.jpedsurg.2020.10.001.
[42] Wamani H, Astrøm AN, Peterson S, Tumwine JK, Tylleskär T. Boys are more stunted than girls in Sub-Saharan Africa: a meta-analysis of 16 demographic and health surveys. BMC Pediatr 2007;7:17. https://doi.org/10.1186/1471-2431-7-17.
[43] Kikafunda JK, Walker AF, Collett D, Tumwine JK. Risk factors for early childhood malnutrition in Uganda. Pediatrics 1998;102:e45. https://doi.org/10.1542/peds.102.4.e45. e45.
[44] Seretew WS, Tesema GA, Yirsaw BG, Argaw GS. Prevalence of stunting and associated factors among under-five children in Sub-Saharan Africa: multi-level ordinal logistic regression analysis modeling. PLoS One 2024;19:e0299310. https://doi.org/10.1371/journal.pone.0299310.
[45] Dembele B. Sex differences in child stunting in Sub-Saharan Africa: a meta-analysis of twenty countries from 2010 to 2016. World Nutr 2025;16:2–10. https://doi.org/10.26596/wn.20251612-10.
[46] Thurstans S, Opondo C, Seal A, Wells J, Khara T, Dolan C, et al. Boys are more likely to be undernourished than girls: a systematic review and meta-analysis of sex differences in undernutrition. BMJ Glob Health 2020;5:e004030. https://doi.org/10.1136/bmjgh-2020-004030.
[47] Munoz N, Litchford M, Cereda E. Nutrition and wound care. Phys Med Rehabil Clin 2022;33:811–22. https://doi.org/10.1016/j.pmr.2022.06.007.
[48] Ibrahim MK, Zambruni M, Melby CL, Melby PC. Impact of childhood malnutrition on host defense and infection. Clin Microbiol Rev 2017;30:919–71. https://doi.org/10.1128/CMR.00119-16.
[49] Koofy NE, Eldin HMN, Mohamed W, Gad M, Tarek S, Tagy GE. Impact of preoperative nutritional status on surgical outcomes in patients with pediatric gastrointestinal surgery. Clin Exp Pediatr 2021;64:473–9. https://doi.org/10.3345/cep.2020.00458.